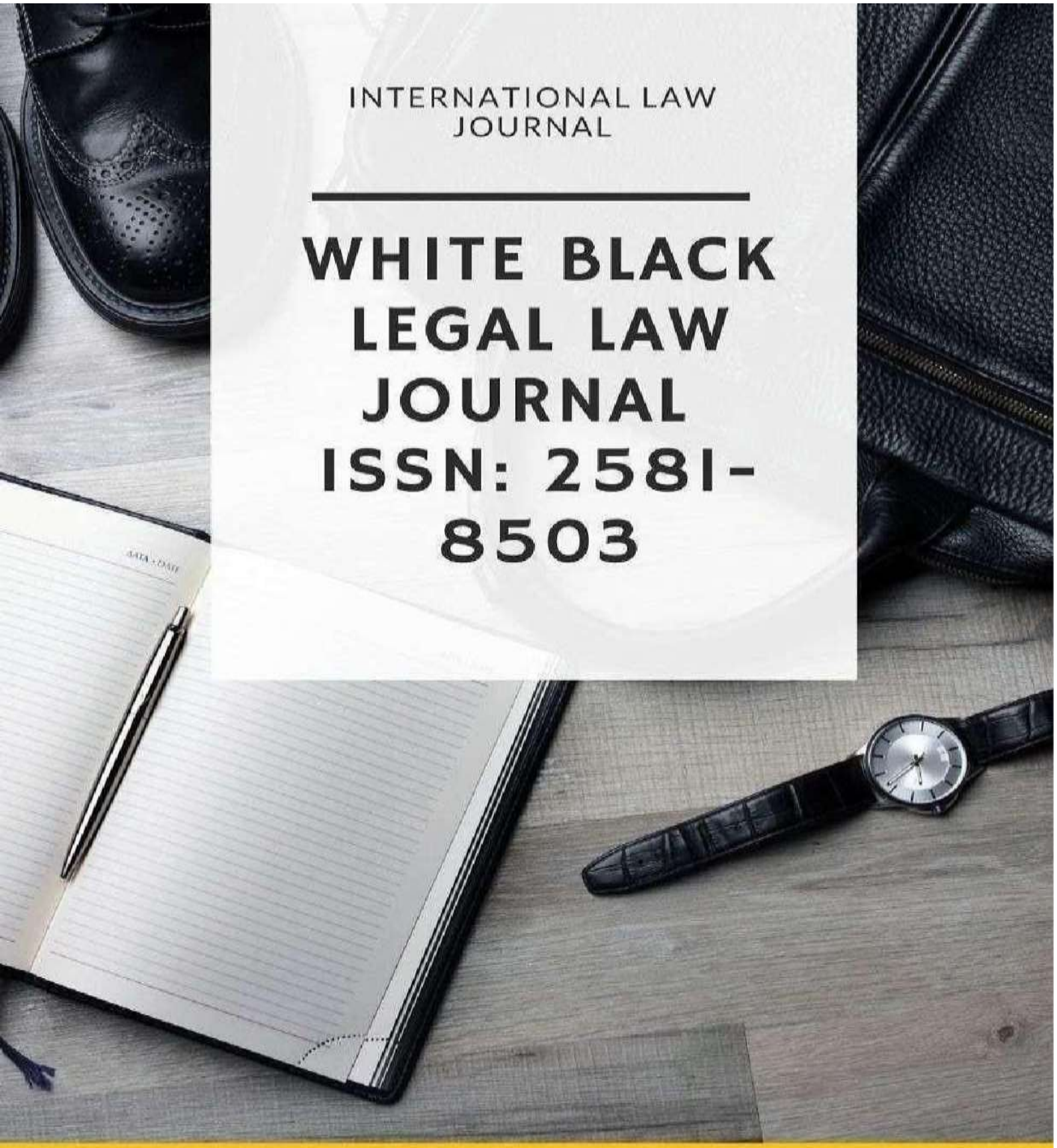


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ASSESSING THE RELIABILITY OF FINGERPRINT ANALYSIS AND ITS LIMITATION AND ACCURACY

AUTHORED BY - PRIYADHARSHINI.M.R

CHAPTER – I

INTRODUCTION:

Friction ridge development may have arisen due to thousands of years of evolutionary development, but it has another use in modern science, specifically forensic science. Today, forensic science refers to any science applied to legal matters. There are many sub disciplines of forensic science, but all apply the topic to matters of law. Legal matters" refer to crimes or prospective crimes as well as civil disputes. No matter what sub discipline you intend to practice, legal matters are decided in a court of law. Courtroom testimony is a critical final step in the analysis of forensic evidence, whether that evidence is bones, insects, or fingerprints. Fingerprint analysis is a cornerstone of forensic science, used to identify individuals based on unique patterns on fingertips.

REVIEW OF LITERATURE:

The present research inevitably utilizes various statutes, case laws, international instruments, books, newspapers, articles, journals, treaties, conventions, dictionaries, encyclopedias and other related documents found in libraries and on that she has the internet, etc. The following is a brief survey of important literature which was utilized by the researcher:

A. BOOKS

1. Stuart H. James and Jon J. Nordby - Forensic Science - An Introduction to Scientific and Investigation Technique - Third Edition
2. Jay A. Siegal and Kathy Mirakovits - Forensic Science The Basics - Third Edition
3. Hillary Moses Daluz- Fundamentals of Fingerprint Analysis
4. Max M. Houck and Jay A. Siegal - Fundamentals of Fingerprint Analysis - Second Edition
5. Roberta Julian, Leone Howes and Rob White - Critical Forensic Studies

B. JOURNALS

1.https://articles.manupatra.com/article-details/Evidentiary-value-of-Fingerprints-in-Indian-Criminal-Justice-System

2. https://www.egattorneys.com/flaws-with-fingerprint-evidence

2. https://www.cronisraelsandstark.com/fingerprint-weaknesses

SCOPE:

This research aims to systematically examine the scientific reliability, practical accuracy, and inherent limitations of fingerprint analysis as a method of personal identification. The study is delimited to two primary domains: Forensic latent-print examination (crime-scene and evidentiary prints). And Biometric fingerprint recognition systems (automated and semi-automated civilian/government applications).

The research will investigate: Uniqueness and persistence of friction-ridge skin (biological and statistical evidence). Accuracy of minutiae-based matching (Level 1, 2, and 3 detail).

Error sources: distortion, substrate, deposition pressure, aging, skin disease, partial prints, smudges. Subjectivity vs. objectivity in ACE-V and the "individualization" conclusion. Impact of emerging technologies (AI, deep neural networks, 3D imaging, contactless sensors).

Validation and proficiency-testing standards. Chemical development techniques for latent prints (Ninhydrin, cyanoacrylate, etc.) beyond their effect on print quality. Palm-print or plantar-print analysis in isolation (only when overlapping with fingerprint methodology).

Ethical, privacy, or data-protection issues surrounding biometric databases (Aadhaar, FBI NGI) except where they directly influence accuracy metrics. Provide a quantified summary of current accuracy rates and confidence intervals for both human examiners and automated systems. Identify the most significant limitations that undermine reliability.

By the end of the study, the research will conclude : As a culminating aspect, the research will critically evaluate the admissibility and evidentiary treatment of fingerprint analysis within the Indian legal framework, particularly in criminal proceedings. This dimension bridges the scientific reliability assessment with its practical judicial application.

RESEARCH METHODOLOGY:

The main purpose of the present study is to examine the reliability and admissibility of Fingerprint Analysis. For the present study, as per the topic view, it is considered that it is ideal and appropriate to adopt the doctrinaire method of research. This involves data collected from

primary and secondary sources such as statutes, enactments, legislations, case laws, bills, conventions (national and international), acts, policies, rules, regulations, law books, journals, articles, newspapers, etc.

HYPOTHESIS:

The hypothecation formed for the present research is that on

1. Is the reliability and accuracy of fingerprint analysis by certified forensic experts truly no better than chance-level performance, or does strict adherence to the ACE-V methodology combined with robust quality assurance protocols enable high levels of reliability and accuracy?
2. Do factors such as poor print quality, challenging substrates, environmental conditions, and examiner bias have minimal impact on the accuracy of fingerprint analysis, or do they substantially increase the error rate in latent print examinations?
3. Is fingerprint evidence inconsistently regarded as strong scientific proof under Section 45 of the Indian Evidence Act, or do Indian courts routinely admit it and accord it high probative value in criminal proceedings?

CHAPTER - II

HISTORY OF FINGERPRINT:

The most effective scientist has a solid grasp of the history and development of the science. Most fingerprint certification tests require knowledge of the history of fingerprint identification. A certification test is a voluntary exam that tests your general knowledge, professional capabilities, and competency. The certification examinations test not only your skill level but also your background knowledge about the science, including its history. The International Association for Identification conducts certification exams for many forensic disciplines. Finally, a working knowledge of history is important because you may be asked questions about historical figures and events when testifying in a court of law. All forensic scientists are expected to testify in court. You may be asked any number of questions regarding a forensic investigation, not just what you did and how you did it, but what is the history behind the science. Are there any historical court cases, events, or influenced the examinations? A strong working knowledge of the science goes a long way to establishing credibility in a court of law.[1]

[1] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No.13

There is anecdotal evidence that Chinese people used fingerprints as a form of sig nature for legal documents more than three thousand years ago. It is not known whether this was done for the purpose of identifying the author of the document and there is no surviving evidence that any basic principles were developed that guided people in identifying fingerprints or comparing them. The first organized use of friction ridges for identification occurred in the late 1870s when William Herschel, a British official posted in India, started requiring that any contracts involving indigenous people contain imprints of their entire hands. Again there is no evidence that he had developed any systematic way of linking these handprints to a particular person. The first article that discussed the use of fingerprints for identification purposes was published in Nature in 1880 by Henry Fauld. He was a missionary in Japan working in a hospital when he discovered that there were unique patterns to human fingerprints. He tried to chemically alter his own fingerprints but the original pattern grew back. He demonstrated that fingerprint impressions could be taken by dipping the finger in ink and suggested that they could eventually be from crime scenes. He even used fingerprints to help the Tokyo police in but glary investigation. Fauld was interested in doing research and eventually appealed for funds to the famous anthropologist, Charles Darwin. Darwin passed on the appeal to his nephew, Sir Francis Galton. Galton did not fund Farid take credit for Fauld's discoveries.

During this same time period, in 1883, a French police expert, Alphorise Bertillion devised the first systematic method of personal identification. His system relied on a carefully constructed and detailed description of a person. This was called the portrait parle and was accompanied by full-length photographs and precise measurements of the body called anthropometry (an-thro pom-e-tree). Bertillionage the complete system was called, was based on the unproven premise that, after the age of about 18, the human skeleton stops growing. In addition, it was thought that all skeletons were different and this was reflected in the uniqueness of the body measurements that he prescribed. Bertillionage was considered a reliable method of personal identification into the beginning of the twentieth century However in 1903 the Will West affair signaled the demise of Bertillionage. Will West was sentenced to Leavenworth Prison in Kansas after being convicted of a crime. At that time, the prison system routinely collected portraits parle on its prisoners to keep track of them. When West was being processed at the prison, officials found that there already was a William West serving time in Leavenworth. His body measurements were virtually the same as the incoming prisoner and in fact the two men looked like twins. Their fingerprints were very different, however. This case showed that Bertillionage could not be relied upon as a means of personal identification, and it quickly fell out of favor and was replaced by fingerprints.

Meanwhile, Sir Francis Galton published a book titled Finger Prints. This book can be found online at www.galton.org. One of the major contributions of this book was that it proposed that all fingerprint patterns could be put into one of three categories: loops, arches, and whorls. Galton also asserted that all fingerprints were unique and that they did not change throughout life.

Once Galton suggested that fingerprints fell into certain patterns, the next step was the development of a classification system. The goal of such a system was to put a set of fingerprints from one person into one of a small number of groups. This would make searching through many sets of fingerprints easier. If a person were fingerprinted and the police wanted to know if that person was already in a data base, the classification of fingerprint sets would make that feasible. As it turned out, two independent classification systems were developed at about the same time Juan Vucetich, an Argentine police officer, became interested in Galton's work and developed the first classification system. It has been continuously refined and is still widely used today in South and Central America. In England, Sir Edward Henry developed a somewhat different classification system. It too has survived and, although it has been modified, is used today in the United States and much of Europe.

ORIGIN OF FINGERPRINT:

The purpose of fingerprints as well as the friction ridges on the palms and soles of the feet is to provide a textured surface for gripping and holding on to objects Fingerprints arise from the skin, particularly the dermal papillae, the layer of cells between the epidermis (the outermost skin layer) and the dermis (the inner layer of the skin). Fingerprint ridges begin forming when the fetus is in the womb at about the 5th week of gestation and are fully formed by the 17th week. From that point on, barring artificial means of alteration, fingerprints do not change throughout life except to grow larger as the body grows. As the friction ridges develop, perspiration glands are formed. These terminate in rows of sweat pores that form on the fingerprint ridges. As perspiration is discharged from the sweat glands, it exits through the pores onto the surface of the ridges. Perspiration residue along with sweat, skin cells, proteins, fats, and other materials is deposited when a finger touches a surface. Since these materials are normally invisible, this image is called a latent fingerprint. A fingerprint that is deposited in paint or blood on a surface and is readily visible is called a patent print. A fingerprint that is

formed in a soft material such as putty is called a plastic print.[2]

CHAPTER - III

ANATOMY OF FINGERPRINTS:

For the purposes of dactyloscopy, a fingerprint consists of the friction ridge skin of the last joint on each finger taken from cuticle to cuticle. Although other joints of the fingers as well as palms and foot soles may have unique ridge patterns, these have not been studied rigorously. Each fingerprint consists of a set of ridges of various shapes and sizes. The major types are

Bifurcations: Ridges that split into two ridges

Ending ridge: A simple straight ridge

Dot: Tiny round ridges

Short ridge: A small, isolated segment of ridge

Enclosure: A ridge that forks and forms a complete circle and then becomes a single ridge again

Trifurcation: A ridge that splits into three ridges.[3]

FINGERPRINT PATTERNS:

The friction ridges in each finger form a pattern. There are three major pattern types. These are the loop, the arch, and the whorl. Arches, loops, and whorls are categorized based on the presence or absence of deltas. Friction ridges that curve and change direction form a triangular intersection called the delta. An arch has no deltas, a loop has one, and a whorl has two. The three major pattern types are further subdivided into a total of eight pat- terns. Every fingerprint forms one of the eight patterns. Arches are divided into plain and tented arches. Radial and ulnar loops characterize the loop category. The whorls have four patterns: plain whorls, central pocket loop whorls, double loop whorls, and accidental whorls.

Arches

The two types of arches, plain and tented, along with the other six patterns. These patterns differ in the severity of the slope of the arch. The tented arch has ridges with a nearly vertical slope, whereas plain arches have more gently sloping ridges. Arches comprise about 5% of fingerprints.

Loops

[2] Jay A. Siegal and Kathy Mirakovits - Forensic Science The Basics - Third Edition - CRC Press Taylor and Francis Group - Pg. No. 218, 219 &220

[3] Jay A. Siegal and Kathy Mirakovits - Forensic Science The Basics - Third Edition - CRC Press Taylor and Francis Group - Pg. No. 221

The two types of loop prints loop patterns, radial loops, and ulnar loops. To prevent ambiguity and increase specificity, the direction that the loop opens refers to the major bones of the forearm the radius and the ulna. The radius is on the thumb side of the forearm and the ulna is on the little finger side. If a loop on a finger opens in the direction of the thumb, it is a radial loop. If it opens toward the little finger, it is ulnar. This means that a radial loop on a finger on the left hand will open in the opposite direction of a radial loop on a finger of the right hand. The curvatures of the friction ridges that constitute a loop produce the triangularly shaped delta where the ridges change direction. Loop patterns have only one delta and make up nearly two-thirds of all fingerprints.

Whorls

Whorl patterns make up the other 30% of fingerprints. There are four types of whorl patterns: plain, double loop, central pocket loop, and accidental. Examples of these four patterns are shown in the second row of fingerprints. The plain whorl has many circular ridges and looks somewhat like a pond after a pebble has been dropped in it. A central pocket loop looks somewhat like a loop print with a small whorl in the middle. A double loop contains two overlapping loops that open in opposite directions. An accidental whorl is the catchall for patterns that do not fit any of the others or that are made up of two types of the other patterns (except for a plain arch). Characteristic of all whorls is that they have two deltas as part of the pattern.[4]

DEVELOPMENT:

Composition of Latent Print Residue

The starting point for understanding latent print development techniques to the fingerprint residue itself. Friction ridge skin, as found on the surfaces d the fingers, hands, and bottoms of feet, has empty their contents onto the skin surface. These sweat glands, called eccrine, produce the watery type sweat composition which forms a basis for latent fingerprint residue. Another type of sweat gland called apocrine located in other parts of the body, produces sweat that contains organic molecules (lipids and proteins) and pheromones. This material can become part of the latent print residue from a person touching those areas of the body. In addition, an almost unlimited variety of substances from the environment can get onto the friction ridge skin and can then be deposited into latent residue when the per- son touches a surface. Thus,

[4] Jay A. Siegal and Kathy Mirakovits - Forensic Science The Basics - Third Edition - CRC Press Taylor and Francis Group - Pg. No. 222, 223

although there are a number of common constituents of most latent print residues based on the composition of sweat, the proportions may vary, and there are many other compounds and materials from the environment that can be present as well.

Most methods for the development of latent prints were developed based on knowledge of the latent print residue composition. Usually, a method known to be capable of detecting or visualizing one of the compounds or elements present in latent residue has been applied to target that compound or element. For the application to be successful, it has to be possible to apply the method to evidentiary fingerprints on the variety of surfaces where they are found, and without destroying the integrity of the impression pattern. The methods commonly employed can be broadly divided into three groups: physical, chemical, and special illumination or a combination of these methods, many of which involve laser or narrow band pass illumination.

It should be noted here (and will be reiterated below) that fingerprints developed in situ a scene must be photographed prior ty lifting or other collection effort. Prints developed in the laboratory or identification must also be photographed to document results as well as the location of the print evidence item, Investigators often face difficult decisions about whether to employ fingerprint enhancement procedures at a scene or seize the evidentiary item and submit it to the lab or identification unit. Many factors will be involved in resolving the matter, including the training and experience of the investigator, how well equipped he/she is at the scene, and whether the evidentiary item can be readily seized and transported.

Physical Methods:

Classically, physical methods are those that do not involve any chemicals or chemical reactions. They work by applying fine particles to the fingerprint residue where it adheres preferentially, thus creating contrast between the ridges and the background. The most well known one is powder dusting a mainstay of latent fingerprint detection for a century or more. Most common powders are inorganic and come in several colors. There is also a large variety of fingerprint brushes available. The principle of powder dusting is simply that the powder particles adhere to the latent residue. Careful use of the proper brush and powder often results in the development of excellent prints. Black powders are generally superior to the other colors. Black powders are produced in a way that yields more uniform particle size and generally produces better results. The lifting of a developed latent impression using transparent lifting tape. The tape lift is mounted on a backing card with a color maximally contrasting to that of the powder (e.g., white backing for black powder) One-piece lifters also known as “hinge lifters are commercially available for this purpose.

A variant of the simple brush and powder combination is the magnetic brush, the original trademark version of which is called magna brush. Actually a steal retractable magnet, not a real at all, the magnetic brush uses special magnetic powder that also can be obtained in several colors. The principle of magnetic powder enhancement is the same as for conventional powder, namely adherence of the fine particles to fatty components of the residue. The magnetic brush technique is more useful on some surfaces that conventional powder dusting, mainly because the magnetic wand can be used to remove any excess powder from the substratum. It also has the potential to be a gentler technique, in the sense that there is no brush, and thus no bristles, so it is less likely to damage the latent print ridges in the brushing process.

Another physical latent print developing procedure involves small particle reagent (SPR) Topically applied by spraying or immersion, the most common formulation of SPR in a fine suspension of molybdenum disulfide in a lotion The particles adhere to the lipid components of the residue. SPR is most commonly used on evidence that has been formerly wet.

Chemical Methods:

The greatest progress in latent fingerprint visualization techniques in the past quarter century has involved chemical and instrumental special illumination techniques. Classically, the chemical techniques were silver nitrate, iodine fuming, and ninhydrin Silver nitrate is not used any longer because there are much better techniques available. The principle of its use lay in the reaction of the silver with the chloride in the fingerprint The silver chloride was then photoreducible to silver, which contrasted with the background. A somewhat related method that still involves silver is called physical developer (PD), and is discussed below.

Elemental iodine is one of the compounds in nature that sublimes, that is, it can pass from solid to vapor without becoming liquid Iodine sublimes easily with only moderate warming. The vapor is directed toward the fingerprint residue with a so-called iodine fuming gun (essentially a plastic blowpipe containing some iodine), or an object to be fumed can be placed in a closed cabinet, which is then filled with iodine fumes. Even though it has bog been placed under the "chemical methods category of latent print development, the iodine probably does not react with any of the components in the residue. It probably interacts with the lipid components in such a way that it is trapped in the residue, giving the tile features a dirty-brown colored appearance The iodine-developed color is not stable in the latent print, however, and iodine prints has to be quickly photographed. There are chemical methods for rendering iodine prints permanent color that will not fade. The traditional method involved using starch solution for that purpose, but 7,8-benzoflavone (α naphthoflavone) treatment is the preferred method today. Iodine fuming is used primarily on inherently valuable items precisely because of its

impermanence.

Ninhydrin develops bluish-purple fingerprints, and is extremely useful on porous surfaces such as paper, but occasionally the bluish-purple color may show sufficient contrast with the background substratum. Ninhydrin is also useful as a pre liminary treatment in a sequential process followed by other chemicals and viewing wonder laser or alternative light source illumination Another significant factor in ninhydrin use for latent prints has been the design, synthesis and evaluation of a series of ninhydrin analogues, perhaps the most important of which is 1,8-diazafluoren-9-ane (DFO Treatment of ninhydrin-developed prints with ZnCl2 (zinc chloride) provides the basis for the use of laser and special illumination methods. The metal salt treatment converts Ruhemann's purple to another compound which can be excited by blue-green light using a laser or alternate light source to yield string fluorescence. Many modifications of postninhydrin latent print treatments have been designed to maximize fluorescence under illumination by commercially available lasers or broadband pass filtered alternate light sources.

There are a host of other chemicals that react with amino acids yielding colored or fluorescent products. However, none have been as important in operational latent print work as ninhydrin (and posttreatments), and DFO. The most important other chemical procedure is treatment with cyanoacrylate esters ("super glue"). Super glue "enhancement" was first observed by Japanese scientists in the National Police Agency. The method quickly caught the attention of latent print examiners all over the world. In the early 1980s, fingerprint examiners working in the U.S. Army Criminal Investigation Laboratory in Japan, and a little later in the U.S. Bureau of Alcohol, Tobacco and Firearms Laboratory, introduced alkyl-2-cyanoacrylate ester (super glue) fuming as a method for latent print development in the United States.

Super glue can be induced to fume, and the fumes will interact with latent fingerprint residue by polymerizing in situ, yielding a stable, even robust, friction ridge impression off-white in color. Items to be processed by glue fuming are usually placed into well-sealed cabinets where the glue is induced to fill the cabinet with vapors. The process requires a certain level of relative humidity, and a moisture source is always placed in fuming cabinets. Glue fuming can be accomplished in a closed cabinet or container without any "acceleration," but it is very slow. Typically, strong alkali or heat is used to accelerate fuming. The progress of latent residue development in the fuming cabinet can be monitored by placing a test latent print onto a piece of aluminum foil, or similar surface, and placing the object into the cabinet where it can be viewed during fuming. Latents underdeveloped with super glue can simply be further fumed. But overfumed latents may be ruined.

Like ninhydrin, glue fuming is an excellent method of developing latent fingerprints. But it may be most useful operationally as an initial step in protocols where the cyano- acrylate-developed prints are further treated and examined. The simplest enhancement of a cyanoacrylate-developed print is dusting it with powder. Other posttreatments of cyanoacrylate-developed prints include "dye stains," which induce luminescence or fluorescence in the residue when it is illuminated with laser or alternate light source at the appropriate wavelength. Gentian violet, Coumarin 540 laser dye, Ardrox, Rhodamine-6G, and other treatments have been used for the enhancement of cyanoacrylate-developed print luminescence under alternate light or laser illumination. The last chemical method we will discuss is physical developer. In spite of the name, physical developer (PD) is a chemical method. It has become common in many laboratories to use PD as a follow-up method to ninhydrin or DFO on porous surfaces, such as paper. While ninhydrin or DFO react with water-soluble components in the latent print residue, PD reacts with the lipid and other water-insoluble components. PD is a photographic-type process based on the deposition of silver onto latent finger- prost residue from a ferrous/ferric redox couple and silver salt mixture in solution. There is a modified procedure developed at the U.S. Secret Service laboratory that employs colloidal gold in addition to silver salt.

Combination/Special Illumination:

Sometimes, a "latent" fingerprint can be visualized by simple oblique lighting. This technique might be considered physical since it involves no chemicals or special light sources. A latent amenable to visualization by oblique lighting also illustrates that the definition of a "latent" fingerprint is operational to large extent. Some kind of pattern was visible in order to have prompted the observer to obliquely illuminate the surface, thus "enhancing" it. Latent prints may also be viewed under alternate light (525 nm) or laser illumination. Alternate light is generally superior to incident white light in revealing ridge detail. "Alternate light sources are exceptionally bright (such as xenon arc) white light sources. White light is a mixture of wavelengths between about 300 and 800 nm on the electro- magnetic spectrum. Alternate light sources are supplied with colored filters, which serve to filter the source light so that the developed latent print can be viewed with light of a narrow wavelength range. The filter is selected to induce illumination at the wavelength known to excite the chemical compounds used in the latent development procedure. Other filters may be used to view the luminescence resulting from the alternate light source excitation. The luminesced light will be of longer wave- length than the excitation, and the filter may provide sufficient contrast between the back- ground and the luminescence of the latent print ridges to give a useful ridge detail image

that can then be photographed and used for comparison. A laser is also a very high intensity light source, but it emits light of a single wavelength (monochromatic light). There are several commercially available lasers. Methods have been developed over the years to take advantage of the excitation wavelengths afforded by these lasers. The undisputed primary developer of laser methods for latent fingerprints has been Dr. E. Roland Menzel of Texas Tech University. The most recent development in this context is development of luminescent, nanoparticles for latent fingerprint enhancement. Refer to the appendices of this volume for more background on the electromagnetic spectrum, and the concepts of light absorption, luminescence and fluorescence.

Bloody Fingerprints and Other Special Situations:

Latent fingerprints in blood or uncertain unusual types of surfaces require special techniques, enhancement modalities or approaches. Bloody fingerprints are almost by definition not "latent" Some type of pattern is visible in the blood, and investigators may recognize that the pattern is probably a fingerprint (or palm or foot print, but that the ridge characteristics are not sufficiently well defined to make the print suitable for comparison. In these circumstances, the use of a bloody fingerprint enhancement reagent might be considered. In this context, an investigator needs to think about whether it will be necessary to attempt to do DNA profiling of the blood that is forming the apparent ridge patterns. There 18 substantial published evidence that latent fingerprint chemical enhancement procedures, including those designed for bloody prints, do not interfere with subsequent DNA profiling by PCR for the now-universal fat least in the United States) CODIS core STR loci.

Bloody fingerprint enhancement reagents can be sprayed or squirted from a wash bottle. Some of the formulas result in a reagent that is not very stable in solution and, thus, has almost no shelf life. Therefore, they need to be prepared shortly before use. Further, there are serious chemical hazards associated with some of the ingredients, so some training is required in the proper preparation and use of these reagents. Many bloody fingerprint enhancement reagents are based on the "per-oxidase reaction chemicals (phenolphthalin, leucomalachite green, tetramethylbenzidine, etc.) commonly used as presumptive tests for blood, tetramethylbenzidine along with hydrogen or sodium peroxide probably being the most common. There are also formulas and procedures based on general protein staining dyes such as Amido Blank and Coomassie Blue R250. They are gets ally less hazardous and easier to use than the "peroxidase reaction" chemicals.

Another special situation involves fingerprints deposited on tape, especially on the adhesive surface. Techniques involving staining with crystal violet were traditionally for this kind of

latent impression. Today, most commonly used method for developing this kind of impression is a material called "sticky side powder." This so-called powder is actually composed of lycopodium (a plane pollen mixed with a detergent and water. The sticky side powder slurry is painted onto the adhesive side of the tape with a brush, an the tape then rinsed off with water. The process can be repeated until the desired contra has been achieved, and it often yields identifiable prints. Sticky side power can be used almost any kind of tape, and works especially well on duct and electrical tape. Yet another "special situation" deserving brief mention is the development of later prints on human skin. A variety of different techniques has been tried, but with only modest success and even that in selected cases! Generally useful procedure has not emerge thus far.

Systematic Approaches:

This concept is probably followed by most latent fingerprint examiners even if they de not identify it as such. The idea is to apply latent development techniques in a way that maximizes the number of identifiable prints The least destructive technique is applied first, and techniques are generally applied in a sequence that allows the maximum number to be used if necessary. Systematic approaches vary according to the surface or substratum on which the latent is located. Porous surfaces, such as paper, for example, call for a different set of techniques applied in a different sequence than nonporous surfaces.[5]

DETECTION AND VISUALIZATION OF FINGERPRINTS:

Fingerprints can be left on many different surfaces at a crime scene. That's why fingerprint experts spend a lot of time carefully searching the scene to find them. Even if a criminal wears gloves, they might still leave fingerprints behind. Gloves can slip off, or the person might take them off for some reason. Sometimes, a glove can even leave a print of its own outer surface on an object.

Patent and plastic fingerprints are generally easy to discover as they have been either left in paint or some other medium or they have been impressed into a mate- rial such as putty. Thus, the major challenge for the fingerprint technician lies in discovering and visualizing latent prints. The science of visualization has been changing rapidly in recent years with many new chemical and physical methods being continually being developed and revised.

Finding and showing latent fingerprints (invisible prints left by sweat, oils, etc.) can happen in

[5] **Jay A. Siegal and Kathy Mirakovits - Forensic Science The Basics - Third Edition - CRC Press Taylor and Francis Group - Pg. No. 3**64 - 370

one step or two separate steps. A newer method uses the fact that fingerprint residue reflects ultraviolet (UV) light differently than the surface around it. This is called the Reflected Ultraviolet Imaging System (RUVIS). It works like this: A special "gun" device shines UV light onto non-absorbent surfaces, such as glass or painted wood. The UV light bounces off the surface and back to a receiver. The system then enhances the reflection and turns the invisible fingerprint into a visible image on a screen. This UV method is great for locating hidden prints quickly and without touching or treating the surface first. However, it is mainly for finding them—the prints still need another technique to make them clear and permanent for collection. Other common methods combine locating and visualizing in one step, such as: Dusting with fingerprint powders (which stick to the oily residues and make the print visible right away). Cyanoacrylate fuming (also called super glue fuming), where chemical vapors react with the print residues to create a white coating that highlights the ridges clearly. These traditional approaches are often used directly at crime scenes to both detect and develop latent prints effectively in a single process.

The method used to detect a latent fingerprint depends on the type of surface. Smooth nonporous surfaces can be easily dusted with fingerprint powders or cyanoacrylate fumed. There are a large number of commercially available fingerprint powders that come in a wide variety of colors. These are applied with camel’s hair or nylon brushes that have very soft bristles. A colored powder is chosen such that its color contrasts with the color of the surface being dusted. For surfaces that have fine texture such as some plastics and hides, magnetic powders are often used with magnetic brushes. The brush is moved across the surface of the object without touching it. This allows the powder to cling to the surface of the fingerprint residues without getting into the cracks in the surface.

Chemical Methods of Fingerprint Visualization:

Fingerprints (specifically latent ones, which are invisible to the naked eye) can be successfully visualized on a variety of common surfaces, depending on whether the surface is porous (absorbent) or non-porous (non-absorbent). The choice of visualization method—particularly chemical ones—relies on reactions between the chemical reagents and components of fingerprint residue, such as lipids (fats/oils), amino acids, chlorides, or water.

Common surfaces include:

Porous surfaces (e.g., paper, cardboard, untreated wood, certain unglazed ceramics): These absorb fingerprint residues, so methods target soluble or reactive components.

Non-porous surfaces (e.g., glass, metal, plastics, polished or varnished wood, glossy paper, aluminum foil): These allow residues to sit on top, making physical adherence or vapor-based

reactions effective.

Other examples: thermal paper, transparency sheets, painted surfaces, leather, rubber, or even textured items like brick (though more challenging). A wide range of chemical methods exists for developing latent fingerprints, and discovering new reagents remains a highly active field in forensic research. These techniques work by triggering chemical reactions between the latent print's residues and specific compounds to produce a visible image.

One of the oldest and most classic chemical approaches is iodine fuming. Iodine exists as a solid at room temperature. When gently heated, it undergoes sublimation—transitioning directly from solid to vapor (gas) without passing through a liquid phase. The violet iodine vapors are then applied to the surface containing the latent print.

The vapors interact primarily with the lipids (fats and oils) in the fingerprint residue, adsorbing onto them and producing a temporary reddish-brown or yellowish-brown image of the fingerprint ridges. However, this visualization is short-lived because iodine continues to sublime and evaporate into the air over time. To preserve the developed print, it must be photographed immediately after it becomes visible. In some cases, applying a starch solution can help fix the iodine and stabilize the image, though photography remains essential regardless.

Important safety note: Iodine vapors are highly toxic, so processing must always occur in a well-ventilated area or under an exhaust fume hood to avoid health risks. Another older method for developing fingerprints is silver nitrate. Silver ions in solution react with chloride ions present in the sweat residue from a fingerprint and form silver chloride as shown in Equation.

$$Ag + Cl \rightarrow AgCl$$

Silver chloride is a white, insoluble powder. It is unstable in the presence of light. which will reduce the silver Ion to silver metal as shown in Equation

$$2AgCl \text{ light} \rightarrow 2Ag + Cl2$$

Fluorescence of Fingerprint:

Around the same period when cyanoacrylate fuming (commonly known as superglue fuming) was being developed and introduced for latent fingerprint visualization—primarily in the late 1970s—researchers discovered that latent fingerprint residues naturally contain various compounds capable of fluorescing under specific wavelengths of light.

Fluorescence is a process in which a substance absorbs energy (typically in the form of light or other electromagnetic radiation) from an external source. This energy excites electrons in the atoms or molecules, causing them to jump to a higher energy level. As the electrons return to their original (ground) state, they release the absorbed energy as emitted light, usually at a

longer wavelength (and thus a different color) than the excitation light. This emitted light appears as visible fluorescence.

In the context of fingerprints, certain natural components in the residue—such as oils, amino acids, or other organic substances exhibit this property weakly on their own. When illuminated with appropriate light sources (e.g., lasers or forensic alternate light sources in the UV, blue, or green range), the residues emit detectable colored light (often in shades of yellow, orange, green, or red), making the otherwise invisible latent print ridges fluoresce and stand out against the background. This inherent fluorescence enables non-destructive visualization and enhancement of fingerprints, especially on surfaces where other methods might be less effective.

One problem with fluorescence is that the concentrations of fingerprint residues are sometimes low and thus, very strong light sources are needed to provide enough energy to induce fluorescence. The first attempts to observe native fluorescence from fingerprints employed an argon ion laser. Some components of fingerprints fluoresce when exposed to this greenish light. However, lasers cannot cause fluorescence in many fingerprints because the fluorescing materials are too sparse.

After the introduction of cyanoacrylate fuming (superglue fuming), forensic experts exploited the exceptional durability of the resulting polymerized print. This tough white deposit on the ridges withstands further processing without damage.

A widely used enhancement technique involves staining with liquid fluorescent dyes, particularly Rhodamine 6G. The dye solution is applied to the fumed fingerprint (e.g., by spraying, dipping, or brushing), then excess dye is rinsed off, leaving it selectively attached to the cyanoacrylate polymer.

The print is next illuminated with a green argon ion laser (or similar excitation source). The Rhodamine 6G absorbs the green light, exciting its electrons, and re-emits bright yellow (or yellow-orange) fluorescent light at a longer wavelength. This produces strong contrast and a glowing ridge detail, especially effective on challenging or multicolored backgrounds when viewed through appropriate filters.

This staining step is non-destructive to the original fumed print and remains a standard method for improving visibility on non-porous surfaces. Today, portable forensic light sources or 532 nm lasers often replace older argon lasers for similar results.[6]

[6] Jay A. Siegal and Kathy Mirakovits - Forensic Science The Basics - Third Edition - CRC Press Taylor and Francis Group - Pg. No. 224 - 228

COMPARISON OF FINGERPRINT:

The goal of developing latent fingerprints is to compare them to known prints from a suspect. Known prints are typically collected on a standard 10-print card, which has spaces for each finger's rolled print (inked or digital). The process involves rolling each finger in ink (or scanning digitally) from cuticle to cuticle and recording it on the card. The card layout:

- Top row: Right thumb to right little finger
- Bottom row: Left thumb to left little finger
- Plus tap prints (or "plain impressions") for thumbs and fingers

Many agencies now use Live Scan, a digital method that scans fingerprints onto a computer, creating a digital 10-print card. This method is faster and avoids ink smudges, making it a more efficient way to store and search fingerprint records.

CLASSIFICATION OF SETS OF FINGERPRINTS:

There are two types of fingerprint comparisons. The first is used when the goal is to identify a particular person from his or her fingerprints. In this case, a complete set of inked fingerprints is taken and sent to a database such as the one at the FBI, which maintains many millions of sets of prints. It would be impossible to manually compare the submitted set of prints to so many sets in the database. The way this is handled is by using a classification system. The one adopted and developed by the FBI is widely used by fingerprint laboratories in the United States today. It is based on the original Henry system. The Henry system used several methods of classifying prints. Each one was based on a different set of characteristics Letter and number symbols were used to describe the type of each classification and the end result looked like a fraction containing a series of numbers and letters in the numerator and denominator.

Careful examination of the Henry primary classification scheme shows that there are 1024 possible fractions. A 1 is added to both the numerator and denominator so that the computers that store and classify sets of prints do not have to deal with 0. Approximately 25% of all sets of fingerprints have a classification of 1 over 1; that is, they have no whorls.

The other classifications within the FBI system also create hundreds or thousands of classes of prints. Using all of the classifications, there are many thousands of classes. When a set of 10 prints is classified and the database is searched. There may be a few hundred sets that match that classification. It is a lot easier for a fingerprint technician to scan these relatively few sets of prints to see if there is a match.

COMPARISON OF SINGLE FINGERPRINT:

Crime scenes rarely yield complete, perfect fingerprints. Instead, examiners more often encounter just one or two partial prints, where only a portion of the full ridge pattern is present. Partial prints can still be matched to a known (exemplar) print from a suspect or database, provided there are enough corresponding friction ridge details (such as minutiae—ridge endings, bifurcations, dots, etc.) visible in both impressions.

A fingerprint examiner compares the unknown (latent) print from the scene to known prints. When they conclude that sufficient points of agreement (corresponding ridge characteristics in sequence, position, and type) exist between the two, without unexplainable differences, they declare an identification—meaning the prints share a common origin (the same finger).

Historically, many jurisdictions enforced rigid numerical standards: examiners had to find a fixed minimum number of matching points to declare an identification. Requirements varied widely some places mandated 10 points, others 12, 16, or more. This inconsistency created confusion: multiple conflicting standards effectively meant no true universal standard.

In 1973, after extensive study, the International Association for Identification (IAI)—a leading professional organization for fingerprint experts adopted a landmark resolution. It stated there is no scientific basis for requiring any predetermined minimum number of matching characteristics (points) to establish positive identification. Instead, the decision should rely on the examiner's expert judgment of the overall quality and quantity of ridge detail agreement.

(This position was reaffirmed in later years, including through subsequent IAI resolutions and the shift to holistic, non-numeric evaluation methods in many countries and agencies.)

Today, most modern forensic protocols (especially in the U.S., U.K., and many other regions) follow this non-numeric, qualitative-quantitative approach (often using the ACE-V method: Analysis, Comparison, Evaluation, Verification), where the examiner holistically assesses clarity, distortion, rarity of features, and correspondence rather than counting to a fixed threshold. There are three levels of friction ridge details:

Level 1 details include the general features and pattern leg., ulnar loop of the fingerprint. These cannot be used for individualization but can be used to exclude a print from comparison.

Level 2 details include particular ridges such as endings or bifurcations. These minutiae (characteristics enable individualization of an unknown print. What is important here is not that the known and unknown prints contain the same number of each type of ridge, but that each detail is in the same position relative to other ridges in each print. In that sense, it is like comparing two samples of handwriting. The individual characteristics lie not in the fact that the known and unknown contain the same number of o and e letters, but that the specific shapes

and sizes of each letter are the same in each exhibit. This is the most familiar way of displaying fingerprint identifications in a court

Level 3 details require a low-power microscope to uncover. These are the minute imperfections in a print such as cuts, scars, edge shapes, ridge contours, and even sweat gland pores. These minutiae are so unique that their presence in the known and unknown print virtually insures individuality. It should be noted, however, that the presence of many of these features depends on how good the image of the print is. Some methods of fingerprint visualization show level 3 details better than others, and this must be taken into account when comparing prints.[7]

AUTOMATED FINGERPRINT IDENTIFICATION SYSTEM (AFIS):

The development of high-powered, easy-to-use, and readily available computers had a profound effect on forensic science. One of the most dramatic advances facilitated by computers is the automated search process for fingerprints. Prior to the development of computerized searching systems, it was impossible for law enforcement agencies to search vast data sets of 10-print fingerprint cards. In the beginning, law enforcement agencies proceeded very slowly in using computers for this task. This was because computers with enough memory capacity to hold large databases of fingerprints were available only at great expense. In addition, the technology for faithfully capturing fingerprint images was rudimentary When AFIS systems first came out, single fingerprints from crime scenes had to be enlarged and then the major ridges traced so they would be of high enough quality for the computers to scan them for searching.

A standard format for storing fingerprint data was developed by the FBI with the help of the National Institute of Standards and Technology (NIST) and the National Crime Information Center (NCIC), Unfortunately, the companies that developed the hardware and software for conducting the searches did not use standard protocols and it was difficult to share data among users of different systems. In 1999, the FBI implemented a new automated system called the Integrated Automated Fingerprint Identification System (IAFIS). This is an entirely digital system that compares a person's set of 10 fingerprints against a database of millions of sets of prints in a matter of a few minutes. In addition, it can search the database for a single, latent print developed from a crime scene.

[7] Jay A. Siegal and Kathy Mirakovits - Forensic Science The Basics - Third Edition - CRC Press Taylor and Francis Group - Pg. No. 228 - 232

All scanned fingerprints can now be digitally enhanced to improve clarity. The problem of incompatibility among different searching systems is being solved by the development of a new generation of workstations that are able to input fingerprints from all the systems commercially available today. When these workstations are fully developed, law enforcement agents can search local, state, and national data bases simultaneously.

AFIS systems operate by anchoring the position of a fingerprint and searching the database using two types of ridges: bifurcations and ridge endings. The data- base is queried to find prints with the same number of these ridges in the same relative positions. The most likely candidates can be displayed for direct comparison. Unlike what is seen in the media, AFIS rarely matches a suspect fingerprint to one individual. The computer system generates a list of possible matches for the finger print examiner to analyze and determine a probable match. The human element is still an integral part of fingerprint identification.[8]

FINGERPRINT AS FORENSIC EVIDENCE:

Fingerprint analysis is a cornerstone of forensic science, with a history spanning over a century. It's been instrumental in identifying individuals, linking suspects to crime scenes, and solving crimes. When a crime is committed, forensic science plays three key roles: determining if a crime occurred, identifying those involved and their connections, and reconstructing the crime scene. Fingerprints, taken from suspects and compared to existing records, are a crucial part of this process, helping investigators piece together the puzzle. They have been used to solve countless crimes over the course of history. Every day, thousands of fingerprint examiners all over the world make fingerprint identifications.

There are three major facets of forensic science: one, to demonstrate whether or not a crime has been committed; two, to identify the individuals involved and how those individuals are associated with other individuals and with the crime scene; and three, to reconstruct the crime scene and the sequence of events that occurred. Fingerprints may be used throughout these processes to provide investigative leads. There may be more than one suspect, victim, or even crime scene. Fingerprints can link a victim to a crime scene, a suspect to a crime scene, and/or a suspect to a victim.

Fingerprints are collected from items of evidence to provide investigative leads. But they are also evidence in themselves. Gardner defines evidence as "anything that tends to prove or

[8] Jay A. Siegal and Kathy Mirakovits - Forensic Science The Basics - Third Edition - CRC Press Taylor and Francis Group - Pg. No. 233

disprove a fact in contention". There are two types of evidence; testimonial and physical. Testimonial evidence refers to verbal accounts such as eyewitness statements or transcripts of interviews. This type of evidence is subjective, meaning it is subject to either intentional or unintentional biases of the individual. Physical evidence includes both physical evidentiary items (weapons, bloody clothing, etc.) and forensic evidence such as fingerprints, trace evidence, and DNA.

A scientist must be unbiased at all times. The key to an impartial forensic examination is integrity: recognizing that everyone has inherent biases and consciously pushing those biases aside. Integrity is defined by the Merriam-Webster dictionary as "firm adherence to a code of especially moral or artistic values."" It also relates the word integrity to "completeness," "soundness," and "incorruptibility." In the discipline of forensic sciences, your personal and professional integrity must be compatible and irrefutable.[9]

FORENSIC ANALYSIS:

The uniqueness of fingerprints makes them a valuable tool in identification. Since no two fingerprints are alike, experts can link a print to its source. Fingerprint involves analyzing two friction ridge impressions to determine if they match, essentially asking: did the same person leave both prints? This process typically involves comparing unknown prints from crime scenes or evidence with known prints to determine the source.

Two key characteristics aid in this comparison:

- Pattern types
- Minutiae

Pattern types-arches, loops, and whorls-are not unique to the individual. They are class characteristics. Class characteristics are those features that place an individual or object in a group or subcategory. Minutiae are individualizing characteristics. Individualizing characteristics are those features that are unique to one particular person or thing. Fingerprint examiners analyze both the class characteristics and individualizing characteristics of fingerprints in order to reach a conclusion.

Class characteristics and individual characteristics are key concepts used to describe and compare many types of forensic evidence, including shoeprints, tire tracks, biological samples, firearms, tool marks, and more.

These terms apply to everyday objects too. Consider a suitcase as an example:

[9] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No. 6

Class characteristics are shared features that place an item into a broad group or category. For a typical carry-on suitcase, these might include: Size (e.g., dimensions), Shape, Color (e.g., red), Material (e.g., nylon), Presence of wheels, Number of zippered pockets (e.g., three), Number of zippers.

When you retrieve your checked red nylon wheeled carry-on with three zippered pockets from a baggage carousel crowded with 300 similar bags, you first rely on these class characteristics to narrow down the possibilities. You scan for red suitcases, then check size, wheels, and pocket count to eliminate most others. Individual characteristics (also called individualizing or unique features) are unique marks, damage, or modifications that distinguish one specific item from all others—even from apparently identical ones in the same class.

These features develop through normal use (e.g., a tear in the fabric, a dented corner, a scuffed area, a loose or missing wheel, a broken zipper pull) or are added intentionally (e.g., a brightly colored ribbon tied to the handle, a personalized luggage tag with your name and phone number, stickers, or scratches from travel). If another suitcase matches all your bag's class characteristics, these unique individual characteristics allow you to confidently identify your own suitcase and rule out its near-twin. In forensic science, class characteristics help include or exclude possibilities, while individual characteristics enable definitive identification or linkage to a single source.

The human brain identifies an object or person in a natural progression from recognizing class characteristics to confirmation by individualizing characteristics. You may not be able to read your luggage tag while your suitcase is coming around the conveyer belt, but you can certainly observe the sizes, colors, and styles of the suitcases as they approach to narrow down the possibilities. When the bag gets close enough for a more rigorous examination of its individualizing characteristics, you can then conclusively determine which bag is yours. Fingerprint pattern types are class characteristics and are therefore used to narrow down the potential field of candidates who may be the source of the fingerprint in question, just like the color and size of a suitcase narrow down the possibility that suitcase belongs to you.

There are three categories of fingerprint patterns: arch, loop, and whorl. There are eight sub pattern types within those categories: ulnar loop, radial loop, plain whorl, double-loop whorl, central pocket loop whorl, accidental, plain arch, and tented arch. Other class characteristics of fingerprints include the presence of creases and scars, the ridge count of a loop, and the whorl tracing of a whorl pat tern. In order to reach a conclusion, the fingerprint examiner must also analyze the minutiae: the individualizing characteristics in a fingerprint. The word "minutiae" refers to small details. The friction ridges that make up a fingerprint pattern are not continuous,

as they may appear at first glance. There are three types of fingerprint minutiae: bifurcations, ridge endings, and dots. A bifurcation occurs when one friction ridge splits into two friction ridges like a fork in a road. A friction ridge may come to an abrupt end, forming an ending ridge. A friction ridge may be short, rather than continuous, with an ending ridge on each end. This is known as a short ridge. The third type of minutiae is the dot, which appears true to its name as a dot between two friction ridges. It is the shortest possible ridge. Minutiae are best observed under magnification. The standard fingerprint magnifier has 3x to 5x magnification, which allows us to com pare the minutiae between unknown and known fingerprints.[10]

UNIQUENESS AND PERMANENCE:

Two main premises form the basis for the science of fingerprint identification:

1. Fingerprints are unique.
2. Fingerprints are permanent.

Fingerprints are truly unique, with no two individuals sharing the same pattern – not even identical twins with identical DNA. This uniqueness is rooted in the random nature of fetal development, where tiny differences in pressure and growth create distinct ridge patterns. Throughout history, fingerprint identification has consistently confirmed this uniqueness, making them a reliable identifier. Fingerprints are also permanent, remaining unchanged throughout life. Formed in the womb, they stay the same despite aging, injuries, or environmental factors. Even attempts to alter or damage fingerprints can't erase their unique patterns, making them a robust tool for identification.

This combination of uniqueness and permanence makes fingerprints a valuable tool in forensic science, helping investigators link individuals to crime scenes and solve cases. It will first address the background, theory, and history of the science of fingerprint identification; followed by a discussion of the development, visualization, and documentation of latent fingerprints from evidence and crime scenes; and finally fingerprint comparisons and courtroom testimony.[11]

CRIME SCENE INVESTIGATION:

Crime scene investigation (CSI) is a forensic analysis of the location and circumstances sur rounding a crime. It comprises gathering investigative, forensic, and physical evidence to link

[10] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No. 7, 8, 9
[11] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis – CRC Press Taylor & Francis Group – Pg.No.11

a sequence of events to reconstruct the crime scene. Evidence can be anything associated with a crime scene that may determine innocence or guilt in a court of law. Fingerprints are a big deal in crime scene investigation. They can make or break a case by linking a suspect to the scene, the victim, or evidence. It's like connecting the dots - fingerprints can:

- Directly link a suspect to the crime scene (e.g., print on a door handle or window)
- Indirectly link a suspect to the crime (e.g., print on a piece of evidence like a gun or tool)
- Connect a victim to the crime scene
- Even help reconstruct what happened at the scene

By analyzing fingerprints, investigators can build a stronger case and get closer to solving the crime. Plus, fingerprints are tough to fake or erase, making them a reliable piece of evidence.[12]

A crime scene can be an unsafe environment. There are many unknown factors It important, first and foremost, to protect yourself from harm. Safety precautions should be taken when handling sharp items (broken glass, syringes, knives, etc.) or working around biological substances such as blood or semen, Gloves should be worn at all times. At scenes contaminated with blood, it is beneficial to double glove (wear two pairs of nitrile or latex gloves at the same time). A mask and eye protection (laboratory glasses or goggles) can also be worn, along with disposable plastic coveralls and boot covers.

Latent fingerprints are compared with known fingerprints. Latent prints at crime scenes may not belong only to the suspect or victim. They also may belong to witnesses family members, bystanders, and normal commercial foot traffic in the vicinity. For example, if a bank is robbed, the point of entry (POE) is the front door of the bank. A crime scene investigator processes the glass doors and recovers 10 fingerprints and 15 palm prints. What are the chances the fingerprints belong to the suspect versus the hundreds of patrons who frequent that bank? It is not possible to collect known fingerprints from every bank patron. In the case of a residential burglary, however, it is possible to collect exemplars from everyone who lives in the home and anyone with legitimate access to the residence.

Exemplars from victims and witnesses are needed to eliminate the latent prints that do not belong to the suspect. These are known as elimination fingerprints. Elimination fingerprints can be taken by using the ink or powder methods. The types of latent prints recovered at the scene determine the types of exemplars it is necessary to collect at the scene. If latent palm prints are recovered, the crime scene investigator collects palm print exemplars as well as fingerprints from the victims and witnesses.

[12] Roberta Julian, Leone Howes and Rob White - Critical Forensic Studies - Pg.No.121

There are myriad situational factors that determine whether or not latents of value are found at a scene. If the scene is indoors, how clean are the surfaces? Are they dirty or dusty? Are the surfaces suitable for developing fingerprints of value? If the scene is outdoors, environmental factors influence whether latents of value are preserved. Dry conditions, wind, rain, sun, and other weather factors may obliterate or deteriorate fingerprints. Fingerprints may be preserved longer in humid conditions and in protected areas. The perpetrator may have worn gloves or touched surfaces with dry hands.

Victims and witnesses watch crime dramas and often have unrealistic expectations of forensic practitioners. This is known as the "CSI effect." The victim may want to know why you are not using a forensic light source, why you did not find fingerprints at the POE, or why you are not collecting DNA evidence. The crime scene investigator can address these questions by politely explaining the actions taken. This is a good time to educate a layperson about the science of fingerprints just as the forensic expert will educate the jury in court.[13]

CRIME SCENE KIT:

A fingerprint analyst's workspace is a controlled lab environment with all the bells and whistles, but a crime scene is a whole different ball game. It's unpredictable, and they have got to bring everything they need with. That's why crime scene investigators pack a crime scene kit with the essentials - it's like a portable toolbox filled with specialized gear to process the scene and collect evidence. They've got to be prepared to get the job done, no matter the conditions.

The following is a list of equipment and supplies necessary for a thorough CSI for fingerprint evidence Gloves, Writing implements, Scales, Magnifier, Rubber/gel lifters, Fingerprint powders (black, bichromatic, magnetic, and fluorescent), Fingerprint brushes (fiberglass, feather duster, and magnetic), Fingerprint lift tape (various widths), Latent print backing cards (black and white), Silicone-based casting material, Light sources (flashlight and forensic light sources), Camera equipment (camera body, lenses, filters, flashes, tripod, and 1:1 latent print adapter), Ink pad, Tenprint cards or elimination print packet, Handiprint System, Evidence packaging (paper bags, boxes, envelopes, etc.), Evidence packaging tape.[14]

FINGERPRINT CLASSIFICATION:

It was apparent to the early fingerprint pioneers that a manageable, consistent classification

[13] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No. 219 - 221

[14] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No.221 &222

system was necessary if large sets of fingerprint files were to be useful for criminal identification. In the United Kingdom and the United States, the classification a systems are variants of the one developed by Sir Edward Henry. In Argentina and other South American countries, a different system based on the me developed by Vuretich has been used.

The modified Henry system assed in the United States is a scheme for the classification of ten-print sets, or a fingerprint card, for one individual. A typical fingerprint card of the kind long used by law enforcement and other agencies to maintain fingerprint records. Use of the classification system enabled efficient searching of large files. Keep in mind, though, that classification is based on having all 10 prints. Thus, a 10-print card from a fingerprinted person can he classified and filed, but you would need all 10 prints from a person to use his/her classification to search in the large file. The system therefore allowed organized maintenance of the large files maintained by many law enforcement agencies, but the files could not easily be searched manually for a single print. It is typical to recover single prints, or sometimes even partial single prints, from crime scenes. Until the development of computerized fingerprint search systems, it was impractical to search large files for a single print because it took so much time. Partial prints could obviously be compared with prints from cards on file, but it was necessary to have a possible suspect or suspects first to know which cards to retrieve for manual comparison.

For years, the fingerprint classification of wanted suspects was shown on wanted posters distributed to police agencies and dis- played in public places such as post offices. The fingerprint classification can be seen in small print

The development and fairly widespread deployment of computerized fingerprint storage and retrieval systems has made searching large files for single and partial prints routine. It has also rendered classification largely unnecessary. At one time not long ago, all fingerprint examiners and identification personnel were extensively trained in fingerprint classification using the modified Henry system, as were many police officers.[15]

PROCESSING THE CRIME SCENE:

The first step to process a crime scene for fingerprints is to conduct a thorough search of the surfaces of interest. The crime scene investigator will concentrate efforts on areas and surfaces the suspect is likely to have interacted with. It is not necessary to fingerprint every smooth,

[15] Stuart H. James and Jon J. Nordby - Forensic Science - An Introduction to Scientific and Investigation Technique - Third Edition - CRC Press Taylor and Francis Group- Pg. No. 361 & 362

clean surface at the scene. Energy should be expended on surfaces relevant to the context of the scene, location, and type of crime. The following is a list of areas to focus on at the crime scene:

- Point of entry (POE)
- Point of exit
- Areas of disturbance or items described by the victim or witness as out of place or moved
- Area where the crime took place, if known
- Ancillary areas such as bathrooms and kitchens
- The path the perpetrator may have taken through the scene (from the POE to disturbed areas to the point of exit)

Once the area of interest has been identified, a visual examination of the surface is the first step in fingerprint processing. Oblique lighting can be used to visualize fingerprints that may not be clearly visible in daylight or direct white light. The best tool for visual examination is a flashlight. A flashlight held at oblique (and even parallel) angles to the surface may reveal friction ridge detail. If fingerprints are observed, they are photographed in situ (in place). Midrange photos are taken to show context. Close-up photographs can be taken with a 1:1 adapter or a macro lens. Plastic fingerprints are also photographed. If the plastic print is durable, it can be cast with silicone casting material.

When all visible fingerprints are recorded, the Surface is processed for fingerprints using the appropriate processing technique. It is often preferable to transport portable items of evidence to the forensics laboratory for processing and analysis. The fingerprint analyst uses chemicals and specialized equipment to visualize latent fingerprints on evidence. Many texts suggest attempting chemical processing methods such as superglue fuming at the scene. This is not recommended for several reasons. First, chemicals and fumes present a hazard to health and property. Second, the laboratory is a more controlled environment, leading to better quality results. In order to assure the best quality fingerprints are developed, evidentiary items must be packaged carefully so as not to damage latent fingerprints.

The powder and brush method of fingerprint processing is the workhorse of crime scene fingerprint development. The technique, known colloquially as dusting for prints, seems simple. However, it takes practice to utilize this method effectively to develop finger- prints of value. Because the fingerprint powder is brushed over the surface, it is possible to wipe away the latent prints rather than develop them. A gentle touch and attention to detail are required.

The following methodology is suggested

First, select a fingerprint powder. The color of the fingerprint powder should contrast with the color of the surface. Black fingerprint powder is often the color of choice because it provides the best contrast on glass surfaces, light-colored glossy painted surfaces, metal, plastic, and finished wood surfaces. Bichromatic powder is effective on dark surfaces where the black powder is not easily visible. Magnetic powder is best suited for smaller areas where a gentler touch is warranted. Fluorescent powder is useful on patterned or multicolored surfaces as well as electronics but can only be visualized with a forensic light source in a darkened room.

After selecting the appropriate fingerprint powder, pour a small amount onto a clean sheet of paper. This is a preferable method to repeatedly dipping the brush into the container of powder. This method keeps the powder in the jar from getting contaminated, dirty, or wet. Contamination is especially relevant since the advent of DNA technology and the emergence of new methods for examining touch DNA.

Remove a fiberglass brush from its protective tube. The brush fibers should not be entangled or contaminated with dirt other than fingerprint powder. A wet or dirty brush should be discarded in favor of a clean, dry brush. Twirl the brush to loosen the fibers Gently tap the brush into the powder to pick up a small amount of powder. Shake or twirl the brush to remove excess powder from the bristles.

Gently pass the brush over the surface using a twirling motion. Be careful to only touch the surface with the tips of the bristles. A very small amount of powder is all that is needed to identify areas with latent prints. When friction ridges begin to appear, concentrate your efforts on that area. Gently pass the brush over the area until you see good contrast and friction ridge detail. Overprocessing may result in accidentally obliterating the print. Work slowly and methodically, When the fingerprint is developed, it is photographed in situ with a scale.

After the fingerprint is documented, it is lifted onto a latent print backing card. Choose a roll of latent lift tape of suitable size. If the impression is a palm print or a set of simultaneous impressions, a wider tape is used. Two-inch lift tape is commonly used for a fingerprint. Pull enough tape from the roll to cover the area surrounding the latent print. Place the end of the tape on the surface next to the latent print. Sweep a finger down the length of the tape over the latent impression with a smooth, even motion. Rub the tape to remove any air bubbles and to make sure the adhesive sticks to the entire area of the impression. In a smooth motion, holding both the roll and the loose end of the tape, pull the tape off the surface. Place the tape onto a latent print backing card in the same way the tape was placed onto the substrate. Rub the tape to remove any air bubbles. Document the location and orientation of the fingerprint after it is

mounted on the latent lift card. Indicate the up direction with an arrow on the front of the lift card. The latent is given a unique identifier, such as L001 or #1. Sketch the location of the fingerprint in its original location on the back of the latent lift card. On many fingerprint lift cards, there are preprinted spaces to fill in the following information:

Sketch/diagram, Case number, Date, Latent lift number, Type of offense, Victim/suspect Address/location Where the prints were lifted from Who lifted the prints (name, initials, and/or ID#) Whether or not the information is printed on the card, it should be included for reference. Documentation is important not only to record the case number and parties involved but also to provide context. The sketch and arrows provide context and orientation. It is often the orientation the location and direction of the fingerprints that is a crucial piece of investigative evidence. Details of the examiner's actions at the crime scene are also documented. There are several common errors made by inexperienced practitioners dusting a crime scene. The inexperienced crime scene investigator may load the brush with excess powder coating the surface and the latent print residue with powder. Recall that fingerprint powder adheres to the oils and moisture in the matrix. If there is too much powder on the surface there will be excessive background "noise." The goal is to develop a fingerprint that has too much fingerprint powder granules to be deposited between, as well as on, the ridges. Another common error is when the practitioner is "heavy handed" with the finger. Print brush Inexperience or impatience may cause the crime scene investigator to wipe the surface with the brush in long strokes, similar to painting a wall. This may wipe away the latent prints or develop prints with drag marks through them. Skillful fingerprint development is gained through training, practice, and experience. All types of crimes, from auto related offenses to homicides, may require the crime scene investigator to dust for fingerprints. The offenses in the following are some of the most commonly encountered crimes.[16]

ADMISSIBILITY OF NOVEL SCIENTIFIC AND TECHNICAL EVIDENCE

Scientific and technical evidence is different from ordinary evidence in several important ways. First, it is presented by individuals who have been accepted by the court as experts. Because of their special knowledge and training, they are allowed to give opinions and draw conclusions that an average person would not be able to make. In this way, experts help explain complex technical information to the jury. Second, since this type of evidence comes from scientists and

[16] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No. 222 - 228

specialists, it may appear highly accurate or unquestionable. For this reason, it is very important to make sure that such evidence is reliable and valid before it is presented in court. Most judges and jurors do not have the technical knowledge needed to judge its accuracy on their own, so legal safeguards are necessary to ensure its trustworthiness. This is especially important when the evidence involves new or innovative scientific methods or tools. Courts must be confident that these new techniques have been properly tested and proven reliable before relying on their results. The development of rules about admitting scientific evidence in court has been shaped by important cases that show how challenging it has been for courts to decide the standards for accepting new scientific methods.[17]

RULES OF ADMISSIBILITY OF EVIDENCE:

In general, any evidence is admissible if it is both relevant and competent It cannot be admitted if only one of these two conditions is satisfied. Both relevance and competence are defined in the rules of evidence

Relevance:

Relevance has two components: materiality and probativeness.

RELEVANCE = MATERIALITY + PROBATIVENESS

If evidence is material, it means that it applies to a matter dealing with the case at hand, not some other case. As an example of materiality, a man is on that for injuring another person with a knife during a street theft. Evidence that the accused had a stash of stolen guns at his home at the time might indicate that he was violent or that he liked to sell guns, but it would not be material to the theft charge. The other component of relevance is probativeness. Evidence is probative if it tends to make a fact or issue more or less probable than if the evidence were not present, Here's another way of expressing this Does the evidence tend to prove something about a fact at issue in this case? For example, a man is arrested on suspicion of distribution of methamphetamine. A search warrant is issued to search his home. No methamphetamine is found, but the police uncover a large number of plastic bags a postal scale, a large bag of a material that is commonly used as a diluent for drugs, and a book that describes in detail how methamphetamine is made is this evidence probative? Most certainly it is. Although this evidence doesn't prove by itself that the accused is a drug dealer, it tends to make this assertion more probable. So, clearly, the test for relevance is two-pronged. The evidence

[17] Max M. Houck and Jay A. Siegal - Fundamentals of Fingerprint Analysis - Second Edition - Chapter 23 Legal aspects of Forensic science - Academic Press - Pg. No. 591

at issue must be both material and probative for it to be considered relevant. But this is only half the story. Even if evidence is highly relevant, it may still be inadmissible because it lacks competence.

Competence:

Competence doesn't mean the same thing in the law it does life. It doesn't have anything to do with the ability to do somethings collection of rules and constraints that evidence must pass must we order to be admissible.

Prejudice: Prejudicial evidence may be highly relevant but as the effect of being viewed negatively by the jury. It can impugn a person reputation or turn the jury against that person. Consider some examples In many jurisdictions, color photographs of an autopsy of the victim of violent homicide may not be admissible because their graphic nature may cause the jury to focus on the gore and blood they depict at the expense of their value as evidence. The jury may view the defendant as being guilty because of the photographs of the victim. Unless the sponsoring pathologist can make a case that these color photograph are necessary to illustrate certain probative facts about the killing these photos may not be admissible. In many cases, black and white photographs are used instead because they do not have the negative impact of color photos. Prejudice is one of the major reasons a defendant's prior criminal record is not admissible evidence of guilt in a trial on a similar charge because the jury may feel that, because the defendant committed similar crimes before, he did it again. Thus, the jury may not properly consider the facts of the present case.

Time wasting: Although attorneys are generally given wide latitude to prosecute and defend in criminal cases, judges will generally not tolerate evidence that wastes time because it is unnecessarily cumulative or repetitive or lacks relevance. Such evidence has the effect of distracting and perhaps even confusing the jury. An example of this is illustrated by a situation in which a large number of people witness the same event and the prosecutor wants to bring all of them in to testify as to what they saw. In such cases, the judge may limit the testimony to one or two representative witnesses.

Unreliable: Reliability is one of the criteria that govern the admissibility of certain scientific (and perhaps pseudoscientific) evidence. Evidence must be reliable if the jury is to be able to weigh it properly in reaching a decision about guilt or innocence. This is also the reason that much eyewitness testimony is discredited in court. Research has shown that, when witnesses experience a startling or surprise event, their recollections can differ widely from one person to the next. Each person reacts to such events differently, and the reactions of these people will bias their perceptions about what they experienced. Another form of unreliable evidence is

hearsay. Hearsay is defined as a statement, made by someone outside a courtroom and not under oath, and that is now being used inside court to prove what it asserts. An example of hearsay would be if person A witnessed a crime committed by person C and tells person B what he saw and then person B offers to testify in court what person A told her about the crime. If the testimony by person B is being used to prove that C committed the crime, this would be hearsay. Some types of hearsay may be considered unreliable because it is difficult or impossible to effectively cross-examine someone who did not witness something but is only repeating something that he or she heard. There are numerous exceptions to the hearsay rule. For example, suppose that a forensic scientist analyzed some plant material and concluded that it was marijuana. This scientist then wrote a report that communicated these findings. At trial, the prosecutor wishes to introduce the report as evidence to prove that the plant material was marijuana. The report may be admissible under certain circumstances even if the scientist is not present, even though it would technically be considered to be hearsay. The difficulty of cross-examining a lab report can be appreciated, but it may be admissible if properly attested and agreed to by both sides. The lab report may also be important when a long period of time has elapsed between the time the scientist analyzed the evidence and wrote the report and the time of the trial. The scientist may not remember doing the analysis in this specific case, and the lab report then stands as the most reliable evidence of what was done to the evidence. This will be discussed in more detail in the later section on laboratory reports.

Improper procedures: Courts generally do not allow surprise witnesses to testify without giving notice to the other side. Evidence is also generally inadmissible if it is offered out of turn or after the proponents have already rested their case. Attorneys are not allowed to present testimony during an opening or closing argument. These prohibitions against Improper evidence are all in place to protect the jury as well as the rights of the accused.

Existence of privileges: In a legal context, a privilege is a protection given someone to protect that person from having to offer testimony against another person. There are certain privileges that exist in many locales that have been created by legislation. They include the attorney-client, doctor-patient, cleric-penitent, and marital privileges. All these in some way are designed to protect sensitive or intimate or otherwise special communications. The attorney-client privilege, for example, protects communications between an attorney and client by allowing an attorney to refuse to testify to such communications. Likewise, a priest is protected from testifying about the contents of confessions made by a member of the congregation. There are two marital privileges: One protects one partner in a marriage from testifying against the other, and the other permits one partner to silence the other partner who wishes to testify. There

are, of course, many exceptions to the privileges mentioned here. In many states, privileges do not exist in the absence of legislation that explicitly permits them. Even in these cases, however, it would be impractical to prosecute someone for exercising a privilege such as a minister who refuses to testify about something heard in a confessional.

Constitutional constraints: Certain provisions of the Constitution, discussed earlier, provide for the exclusion of evidence and/or testimony where violations have occurred. They include evidence seized in violation of the Fourth Amendment and testimony of self-incrimination covered by the Fifth Amendment.

In summary, evidence will be admissible in court only if it is both relevant and competent. This applies to all evidence in a criminal case. The following section turns to the question specifically of the admissibility of scientific or expert evidence. Because of its technical nature, this subject matter is treated somewhat differently from non-scientific evidence.[18]

EXPERT TESTIMONY:

In addition to analysing evidence, one of the most important responsibilities of a forensic scientist is to appear in court and testify as an expert witness. This role distinguishes forensic science from other scientific fields. Not all skilled scientists are comfortable working in the stressful environment of a courtroom, and they may struggle to present their findings effectively. Likewise, someone who is a strong speaker may not necessarily be a competent scientist.

A successful forensic scientist must be capable in both areas—scientific analysis and clear, confident courtroom testimony. The following are some guidelines and tips for becoming an effective expert witness.[19]

GETTING INTO COURT:

Not every case that a forensic scientist works will go to trial. In fact, opportunities for testifying may be infrequent and irregular. The scientist may not be summoned to testify for a number of reasons, such as the defendant may plead guilty, a plea arrangement may be made for a lesser sentence, the attorney may decide that particular scientific evidence isn't needed for trial, or the charges may be dropped. The first notice that someone is required for testimony will often

[18] Max M. Houck and Jay A. Siegal - Fundamentals of Fingerprint Analysis - Second Edition - Chapter 23 Legal aspects of Forensic science - Academic Press - Pg. No. 588 - 591

[19] Max M. Houck and Jay A. Siegal - Fundamentals of Fingerprint Analysis - Second Edition - Chapter 23 Legal aspects of Forensic science - Academic Press - Pg. No. 603

be a subpoena giving the defendant's name, the jurisdiction, the date and time that the subject is requested to appear, and contact information for the requesting attorney. When a subpoena is received, the scientist should call the requesting attorney as soon as possible to establish what is being requested. Coordination with the requesting attorney is crucial to success as a witness on the stand. Most attorneys know very little about science and will need to discuss the intricacies of the scientist's expertise to be prepared for court. In this respect, the forensic scientist is a teacher for the attorney, and it is up to the scientist to help the attorney understand what was done in this case and what can be said and what cannot be said. Insisting on a pre-trial conference, coming prepared, and being helpful are the best ways to make a testimony experience proceed as smoothly as possible.

TESTIFYING:

When a forensic scientist steps into a courtroom to testify, he or she is, in essence, entering a foreign realm where only some of the rules of science apply. As Lee Goff, a noted forensic entomologist, has described it in his book, A Fly for the Prosecution, Academics and the legal system do not usually coexist in comfort. The laws of science and the rules of evidence have little in common. In theory, Academia functions on the principle of collegiality. In theory and reality, the American legal system is adversarial. The average academic entering the legal system is in for a tremendous culture shock. The legal arena has its own rules, and most, but not all, apply to scientists as experts, so they must abide by the rules; experts, however, have leeway in the courtroom that no other witnesses have. It is a strange intersection between science and the law where even words have different meanings. Consider, for example, the word "error." To a scientist, an error is something that occurs naturally in all measurements and is accounted for in the statistics that are generated, such as "standard error of the mean." An error in science cannot be avoided and is reported in due process. An attorney, on the other hand, hears the word "error" and thinks: Mistake! The scientist has just admitted to doing something wrong, in the lawyer's view, and has opened the door for further questioning. This "clash of cultures" does not always serve either side very well and may obscure what both parties seek.

BEING WITNESS AND AN EXPERT:

Ordinary witnesses (also called lay or fact witnesses) are generally limited to testifying about what they personally perceived through their five senses sight, hearing, touch, smell, and taste. Their testimony must be strictly factual and based on direct observation or experience. In nearly

all cases, they are prohibited from offering opinions, interpretations, guesses, speculation, or hypothetical scenarios. Expert witnesses, by contrast, are permitted and often expected to provide opinions, conclusions, and interpretations about evidence or circumstances that fall within their specialized field of knowledge. Courts allow this exception because: The expert possesses specialized training, education, skill, or experience that far exceeds that of the average person (including judge and jury). Their expert opinion is considered helpful and relevant to assist the trier of fact (judge or jury) in understanding complex technical, scientific, or specialized matters and reaching a fair decision.

Because of their demonstrated expertise, these witnesses can explain, interpret, and draw inferences from evidence in ways that lay witnesses cannot. Scientific evidence, when presented through a qualified expert, can be especially persuasive and powerful in influencing the outcome of a case. [20]

COMPUTER BASED FINGERPRINT FILES:

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

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

[20] Max M. Houck and Jay A. Siegal - Fundamentals of Fingerprint Analysis - Second Edition - Chapter 23 Legal aspects of Forensic science - Academic Press - Pg. No.603 & 604

state system might not have them, for example:

AFIS can be seen as one of the three significant classes of electronic databases for law enforcement purposes that are now a permanent part of the landscape. The other two are CODIS (Combined DNA Indexing System), which holds DNA profiles, and NIBIN (National Integrated Ballistic Information Network), which holds searchable image information from fired bullets and cartridge cases. Generally it can be said that each of these databases holds two types of files or profiles. One type is the knowns. In the AFIS case, this file contains the prints of known individuals. Any questioned specimen, image or profile can be searched for in the "known" database, and if it is found, its source is thereby identified. The other type is often called the "forensic" file or database. It consists of images or profiles from unsolved cases, the sources of which are not known. In the AFIS case, for example, the forensic file contains images of developed latent single fingerprints from unsolved cases. The per- son whose fingerprints these are has not yet been identified. The file is valuable to investigators, however, in that it allows cases to be connected by the fingerprints that were not obviously related. Such connections can allow investigators to share information and leads, thus increasing the probability of apprehending a suspect.

AFIS has become a successful tool in the apprehension of unknown offenders. Traditionally any person arrested would have a 10-print card that is entered into the AFIS system. Many job applicants will also have a 10-print card in the system. The number of cases solved by AFIS in the United States is difficult to determine, but the national aver- age of latent prints entered into AFIS that will be deemed an identification by a latent print examiner is around 15%. This average of latent prints identified by AFIS can vary among jurisdictions. It is dependent on the knowledge and skill of the individual entering the latent or unknown impressions (usually forensic scientists), and also by the individuals that submit and register the known fingerprint cards (usually technicians or police personnel).

The FBI has made their criminal database of known fingerprint cards available to other law enforcement agencies. This systems is called the Integrated Automated Fingerprint Identification System, IAFIS, Using the LAFIS system, a latent print examiner can searching state or several states. This is the national unknown latent impressions in a neighbor criminal database maintained by the FELI of all of the 10 print cards received from all over the country. To date this system has been very successful in developing leads and sometimes solving unresolved cases.

Today, AFIS must be seen as part of a much larger picture that includes an array of auto- mated systems for human biometrics-the use of some type of body metric for identification. It may be

fair to say that the Bertillon system of anthropometry described above was the first well-defined system of human biometry, leaving aside the pre-19th century uses of fingerprints as means of human identification. While criminal identification and related law enforcement applications of automated fingerprint systems are obviously very important, fingerprints along with other biometrics (such as retinal or iris patterns, voice recognition hand geometry, etc.) have increasingly been incorporated into automated identification systems for other purposes. These systems may control entry and/or access into computers or structures, identification of persons for security purposes, to prevent identity theft, and to help control welfare or social services fraud.[21]

TYPES OF EVIDENTIARY FINGERPRINT:

At crime scenes and/or on items of evidence, there are essentially three types of fingerprints that may be encountered: patent, plastic, and latent. A patent (or visible) print is one that needs no "enhancement" or "development" to be clearly recognizable as a fingerprint. Such a print is often made from grease, dark oil, dirt, or even blood, rendering it visible and recognizable, and possibly even suitable for comparison without additional processing.

A plastic print (might be called "impression" or "indented" print) is a recognizable fingerprint indentation in a soft receiving surface, such as butter, silly putty, tar, etc. Such prints have distinct three-dimensional character, are immediately recognizable and often require no further processing

A latent print is one that by definition requires additional processing to be rendered visible and suitable for comparison. Processing of latent prints to render them visible and hopefully suitable for comparison, is called development, enhancement or visualization. An enormous amount of literature has grown in this subject in the past 30 years or so. Many great strides have been made in the areas due to clever applications of chemistry and physics principles coupled with better understandings of the composition of latent residues. In many ways, these advances are as Impressive and important as the progress made in applying DNA typing techniques to biological evidence though they have not received even a fraction of the publicity that has been given to DNA.

[21] Stuart H. James and Jon J. Nordby - Forensic Science - An Introduction to Scientific and Investigation Technique - Third Edition - CRC Press Taylor and Francis Group- Pg. No. 362 - 364

RECOGNITION, COLLECTION AND PRESERVATION OF FINGERPRINT EVIDENCE:

Fingerprints are among the best and most probative of all types of physical evidence for associating people with locations or objects. Accordingly, fingerprint evidence should be sought at any type of scene, and particularly at areas of crimes committed by unknown perpetrators. Recognition of fingerprint evidence at a scene is not unlike recognition of evidence in general. It requires training and experience. Once recognized, the location of fingerprint evidence should be appropriately documented by photography, notes, and sketches as appropriate. As a general rule, objects believed to have latent fingerprints on their surfaces should be collected intact and submitted to the laboratory's latent print section for examination. If collection of the object or surface is impossible or impractical, investigators must consider applying latent development techniques at the scene, or requesting assistance from personnel trained to do so. Sometimes, developed prints may be collected using tape-lift or other methods. Other times, the developed print may have to be carefully photographed because the photograph will be the only permanent record of the evidentiary print. Like other evidence, collected fingerprint evidence such as lifts or photographs should be care- fully documented to preserve the chain of custody from the scene to the courtroom.[22]

FINGERPRINT IDENTIFICATION:

Everything in this chapter so far indeed, the reason there is a chapter on this subject at all comes down to the use of fingerprints as a means of identification of persons. As noted earlier, the uniqueness of fingerprints in a matter of common knowledge. Advertisements and commercials commonly use phrases like as unique as a fingerprint etc. Even the term "DNA fingerprints, as undesirable and sometimes misleading as it is, was coined to reflect the notion that a DNA profile might be as individual as a fingerprint. Infrared spectra of pure compounds are sometimes called "chemical fingerprints". But most people have never given much thought to the process by which fingerprint identification is actually done.

David Ashbaugh, among others, has noted that fingerprint individuality, and therefore fingerprint identification, rests on four premises 1. Friction ridges develop during fetal growth before birth in their definitive form 2. Friction ridges remain unchanged throughout life with the exception of permanent sears. 3. The friction ridge patterns and their details are unique and

[22] Stuart H. James and Jon J. Nordby - Forensic Science - An Introduction to Scientific and Investigation Technique - Third Edition - CRC Press Taylor and Francis Group- Pg. No. 364 & 371

not repeated 4. The ridge patterns vary within certain boundaries, which allows the patterns to be classified.

Fingerprint examiners are generally extensively trained and required to accumulate significant experience before being entrusted with the responsibility of making identifications. Thus, in addition to the general principles and approaches used to make identifications, the knowledge, training and experience of the examiner also comes into play.

In a law enforcement context, identifications are always made by trained, and often certified, examiners. Sometimes, inked prints from a person may be compared with a set of inked prints on file to determine if they came from the same individual. But more commonly, the examiner will be comparing a developed latent print with inked prints from a known person or persons. AFIS searches can quickly narrow down the number of possible matches to a manageable size, but an examiner, not a computer, makes the actual identification.

In the case Latent examinations, perhaps the first issue comes into play is determining what is called "suitability of the latent fingerprint for identification there, the examiner must decide if sufficient quality and quantity of the ridge detail is present in the latent to make it possible to compare with a known print. This determination also requires training and experience. Once a latent print is evaluated and determined to be suitable for comparison, it will then be compared to the known prints on fingerprint cards. Such knowns might be obtained through an AFIS search, or because certain persons are suspected and their prints are taken or are already on file The overall process an examiner uses has been described by Ashbaugh as "ACE-V that comprise the formal process, followed by verification. The examiner must first analyze for the analysis, comparison, and evaluation the latent, determine its proper orientation, decide if there are any color reversals or other unusual circumstances, decide suitability, then proceed to the comparison. Comparison with the known takes place at several levels. The overall pattern and ridge flow what Ashbaugh calls level D must be examined. Next, the individual characteristics (minutiae) are compared as to type of features and their locations (what Ashbaugh calls level II) Finally another level of detail (Ashbaugh's level III, consisting of pore shape, locations, numbers, and relationships, and the shape and size of edge features, is compared. Any unexplained difference between the known and latent print during this process would result in the conclusion that the known is excluded as a source of the latent. This is one possible outcome of the evaluation decision. If every compared feature is consistent with the known, and there are enough features sufficiently unique when considered as a whole, the examiner concludes an individualization. Since peer review is a feature of most scientific endeavors, Ashbaugh notes that verification of conclusions by an independent examiner is a necessary practice.

FINGERPRINT IDENTIFICATION PROFESSION:

In the past several decades, a number of trends have worked to professionalize finger print examiners more than they have ever been in the past. People entering the profession have more formal education today than was once true. The extraordinary progress in latent development and recovery methods noted above has demanded that fingerprint examiners understand much more chemistry and physics than ever before. The IAI las been a positive force, through the facilitation of discussions, encouragement of research and scientific approaches, and through its professional publication, the Journal of Forensic Identification. Journals are commonly and routinely the primary, peer-reviewed source original research in scientific fields, and the IAI journal rose to fulfill that role for the fingerprint and identification sciences especially under the editorship of David Grieve. The LAI has also been the primary peer standard- setting group in the science of fingerprints. Today, there is a scientific working group on friction ridge analysis, study, and technology (SWGFAST) that started in 1995. Like all technical working groups, its purpose is to arrive at consensus standards for the professional area to arena. In the 1990s, DNA typing and profiling became a major feature of forensic science. That, coupled with the Supreme Court's Daubert v. Marion Merrell Der et al, decision, has forced many forensic disciplines besides DNA to take a careful look at that underlying assumptions and criteria for evaluating matches and identifications. These trends are likely to continue.

Fingerprint examiners today hem wide range of educational background. The SWGFAST recommends that trainees hired in 2005 and later should have a 4 year degree. There is also a considerable period of training involved in learning the fingerprint specialty Individuals may be hired in some agencies primarily as AFIS technicians, to maintain systems, scan images into the system, and so forth. They do not need the level of training required to be an independent latent print examiner. The IAI has a certification program for Intent fingerprint examiners, and more and more employers are requiring that certification as a condition of employment. The certification requires passing a challenging written test, demonstrating competency in latent print comparisons, and then maintaining a record of activity and continuing education during the certification period. Although fingerprints may be the oldest of the forensic science disciplines, it is still one of the most interesting and exciting. More cases may be solved by fingerprints than by an other single type of physical evidence.[23]

[23] Stuart H. James and Jon J. Nordby - Forensic Science - An Introduction to Scientific and Investigation Technique - Third Edition - CRC Press Taylor and Francis Group- Pg. No. 371 - 373

EXPERT WITNESS:

Regardless of the type of fingerprint analysis conducted, all fingerprint examiners with forensic scientist, the fingerprint analyst must not only conduct scientific analyses criminal investigation. Bringing a suspect to justice, or exonerating the innocent, is the goal o communicate their results in a court of law. The courtroom is the final stop for any crime forensic analysis. Most criminal cases never make it to court. The accused either takes a plea deal (admis guilt and accedes to a predetermined punishment) or is never brought to trial. Regardless of how often a fingerprint analyst testifics, it is critical that all forensic scientists receive training to prepare for their testimony. The fingerprint analyst should practice testifying by participating in mock court sessions. Mock testimony gives fingerprint analysts practice so they can plan out their testimony, know what to expect, and be prepared. A forensic scientist who testifies in court may be considered an expert witness if accepted as an expert by a judge in a court of law. An expert witness is anyone who knows more about a particular topic than the average person. This is defined by the Federal Rules of Evidence (FRE), which govern how evidence is presented in a court of law. Federal Rule of Evidente 702 (FRE 702), adopted in 1975, applies to scientific and technical experts, as follows: If scientific, technical, or other specialized knowledge will assist the (judge and/or jury) to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case. In other words, an expert in a particular field may testify to their opinion if the opinion is based on commonly accepted facts or data. Science is based on data that are rigorously tested and published. Forensic science is a branch of science and is therefore subject to rigorous testing, peer review, and publication. The difference between a lay witness and an expert witness is an expert witness can testify to their opinion. A lay witness must only testify to what was seen, experienced, or heard. He may not give an opinion or testify to what someone else said or witnessed. The following is an example of the difference between lay witness testimony and expert witness testimony.[24]

MODUS OPERANDI:

Modus Operandi The successful identification of a latent print is only the beginning of an

[24] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No. 262 - 263

investigation. A fingerprint identification provides an answer to "who," but not to "what, when, or how in the investigation of a crime scene, knowledge and understanding of human behavior are invaluable as clues to where to find the best physical evidence, including latent prints. The more an investigator understands about the how and why of a suspect's criminal actions, the easier it is to concentrate on those areas that will be most productive in the hunt for evidence. Like the rest of us, much of a criminal's behavior is habitual. Certain burglars prefer certain entry points and particular methods of entering and searching. These habits become a criminal's modus operandi.

An investigator's experience helps them recognize patterns in crimes, known as the modus operandi (MO). This can include things like:

- Breaking in using a specific method (like pliers on doorknobs)
- Targeting specific items (like jewelry in master bedrooms)
- Acting out in peculiar ways (like making a sandwich or leaving messages)

These patterns can:

- Link multiple crimes to the same person
- Give clues about the suspect's identity
- Provide valuable evidence for prosecution

Sometimes, these quirks become a signature, making it easier to track down the perpetrator. It's like a criminal's fingerprint - unique and revealing.[25]

FINGERPRINT COMPARISONS:

The purpose of processing latent fingerprint and collecting known fingerprints is to compare one to the other to determine whether they come from a communion source (i.e. whether or not the same person made both the known print and the latent). A latent print identification is possible due to the two premises of fingerprint analysis: friction ridges are but unique and permanent.

The fingerprint analysis process unfolds differently depending on the investigation's stage. When a suspect's identified, their known fingerprints (collected via powder, ink, or digitally) are compared to latent prints found at the crime scene. These latent prints are typically developed using powders or chemicals and then documented either physically on lift cards or digitally.

[25] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No. 228

If there's no suspect yet, investigators follow a different path: They first compare the latent prints to elimination prints - these belong to individuals who had legitimate access to the scene, such as homeowners, witnesses, or first responders. This helps filter out irrelevant prints. Next, they search the remaining latent prints in the Automated Fingerprint Identification System (AFIS) database. AFIS allows for rapid searching through vast collections of prints, potentially linking the crime scene prints to a known individual in the system.

This process helps investigators generate leads, identify suspects, and piece together evidence. The power of AFIS lies in its speed and scale, making it a crucial tool in modern forensic science.

A latent print will not usually be an exact replica of any other latent print or known print from a single source. Even when a person presses the same finger onto a surface several times, each latent impression will vary slightly. Factors such as the development technique used, the pressure applied during deposition, distortion, the nature of the surface, the amount of residue present on the friction ridges, movement at the time of contact, and the skin's elasticity all influence the appearance of a developed latent print. These same variables can also affect the appearance of a known print recorded on a tenprint card or displayed digitally. In examining a latent print, an expert focuses on the overall pattern type, ridge count, ridge flow, and, most importantly, the nature and positioning of minutiae along the friction ridges.

Comparing fingerprints is an exercise in pattern analysis. Some people are more adept than others at pattern analysis. The successful latent print examiner is detail oriented and can perceive detail without succumbing to inherent biases imposed by the human mind.[26]

ACE- V:

ACE-V is a scientific methodical evaluation of level one, two, and three detail in context. Regardless of the medium used to record the known fingerprints-ink, powder, or digital- latent print examiners use a process known as ACE-V to perform fingerprint comparisons. This methodology standardizes the comparison process to ensure that every examiner follows the same steps to identify the source of any latent fingerprint. The ACE-V process is not only used to identify the source of a fingerprint but also to exclude an individual as the source of the fingerprint. An exclusion conclusion is just as valuable as an identification conclusion. ACE-V methodology was developed as an approximation of the scientific method. The components of the scientific method are

[26] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No. 238

- Observation
- Hypothesis
- Experimentation
- Analysis
- Conclusion
- Peer review

The ACE-V method was developed to standardize fingerprint comparisons and to give the science legitimacy in the greater scientific community. It was initially standardized by the Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGEAST) In 2009 and revised in subsequent instructive documents

ACE-V is a systematic approach to looking at the latent print and making a determination detailed examination of the minutiae and other features of the fingerprint. Vanderkolk describes the decision-making process as follows:

The examiner transitions through the examination by analyzing, comparing, and evaluating the details of the prints through critical and objective comparative measurements of the details of general ridge flow, specific ridge paths and ridge path lengths, the sequences and configurations of ridge paths and their terminations, and the sequences and configurations of edges or textures and pore positions along ridge paths.

The examiner makes a transition from insufficient knowledge, through doubt, to knowing and belief. The examiner bases this knowing on the previous training, experience, understanding, and judgments of self and a belief in the legitimacy of the training, experience, understanding and judgments of the collaborated community of scientists.

The examiner's final determination-identification, exclusion, or inconclusive-is the result of a qualitative and quantitative analysis. Quantitative analysis refers to countable data such as statistics or countable observations. Qualitative analysis refers to data that are not countable but scientifically valid nonetheless. Fingerprint analysis is quantitative because there are aspects of fingerprint analysis that involve counting ridges, minutiae, etc. The analysis is qualitative because the examiner's opinion is subjective, meaning the conclusion is based on the personal opinion of the examiner. The examiner's opinion is based on training, experience, and education.[27]

[27] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No. 241 - 242

EVALUATION:

The evaluation stage is like the conclusion step in the scientific method. At this point, the examiner decides whether the latent print (the unknown print found at a scene) and the exemplar (the known print) come from the same person, from different people, or whether there is not enough information to make a decision.

This decision depends on how confident the examiner feels about the amount and clarity of details in both prints. The examiner looks at both the quality and quantity of features in the latent print and compares them with the known print. Their training, knowledge, and experience also play an important role in making this judgment.

The quantitative factors refer to the number and sequence of minutiae points (level two details) seen in the prints. The qualitative factors refer to overall features such as ridge flow, pattern type, scars, pore size, and pore location (level one and level three details).

VERICATION:

The verification stage is similar to the peer review step in the scientific method. It acts as a double-check of the first examiner's decision. A second fingerprint examiner independently performs the same ACE-V steps and arrives at their own conclusion. Verification is important because it helps prevent errors. If a mistake is made, an innocent person could be punished or a guilty person could escape justice. Either outcome is unacceptable.

The second examiner will either agree with or challenge the first examiner's conclusion. The final result—whether identification, exclusion, or inconclusive—is reported only if both examiners reach the same conclusion.[28]

FLAWS:

Fingerprint evidence has several weaknesses. The examination process can be subjective, meaning it depends partly on the examiner's personal judgment. There is also a risk of examiner bias, especially if the examiner is exposed to background information about the case. Crime scene prints are often incomplete, smudged, or of poor quality, making comparison more difficult. There is no universal standard for how many matching points are required for identification, and matching partial prints can be particularly challenging. Environmental conditions can also affect the quality of prints, and in rare cases, fingerprints may be

[28] Hillary Moses Daluz- Fundamentals of Fingerprint Analysis - CRC Press Taylor & Francis Group - Pg. No. 244 & 245

intentionally altered. All of these factors increase the possibility of false positives (wrongly identifying someone) or false negatives (failing to identify the correct person).

These problems can have serious consequences, including wrongful convictions or the release of guilty individuals. Because examiners must sometimes rely on subjective judgment—especially when dealing with partial or unclear prints different experts may reach different conclusions when analyzing the same evidence. Bias is another concern. If an examiner is influenced by case details or expectations, it may affect how they interpret the print. This highlights the importance of maintaining objectivity and minimizing bias in fingerprint analysis.[29]

INCONSISTENT COMPARISON STANDARDS

Fingerprint evidence has been used in court for a long time, but unlike DNA testing, there is still no single, agreed-upon scientific standard for deciding when two fingerprints match.

Fingerprint experts compare a suspect's print to one found at a crime scene by looking at tiny ridge details and patterns with their eyes. However, different experts often use different rules. There is no fixed number of matching points everyone must agree on to call it a match.

One expert might say a small or unclear (partial) print is enough to identify someone, while another expert might say the same print is too unclear and cannot be used. This difference in opinion and approach makes fingerprint evidence less reliable because it depends heavily on the personal judgment of the individual examiner.

VULNERABILITY TO HUMAN ERROR AND BIAS:

Fingerprint analysis can go wrong because of human mistakes and biases. Examiners are people, so they can get tired, distracted, or stressed. When that happens, they might miss important details or see things that aren't really there—especially when the fingerprint from the crime scene is only partial or blurry. In those cases, it's hard to be 100% sure whether it's a match or not.

Another problem is bias. If the examiner already knows the suspect has a criminal record, or if the police really want this person to be the match, the examiner might (without meaning to) lean toward saying "it's a match" even when the prints don't actually line up perfectly. Studies have shown that when examiners are told extra information about the suspect, they are more likely to call it a match—even in cases where there is no real match.

[29] https://www.egattorneys.com/flaws-with-fingerprint-evidence

Finally, there is still no single worldwide rule that says exactly how many matching points (and how clear they must be) are needed to officially declare "this is the same person." Because of this, one expert might look at four matching details and say "that's enough," while another expert might look at the same four points and say "that's not enough to be sure." This difference in opinion makes fingerprint evidence less consistent and trustworthy.

VARIATIONS IN FINGERPRINT QUALITY:

The quality of a fingerprint found at a crime scene can make a big difference in how accurately it can be matched to a person.

When police take fingerprints the normal way (like at a station), they usually get clear, full prints. But fingerprints left accidentally at crime scenes—called latent prints—are often only partial, smudged, blurry, or stretched out of shape.

Things in the environment, like wetness, heat, or the type of surface (rough, smooth, dirty, etc.), can make the print even worse. Even a fairly good print can look different from the real finger because of how the finger touched the surface—for example, if it pressed hard, slid a little, or touched at an odd angle, the ridges can get distorted or squeezed.

Another problem is making hidden (latent) prints visible so they can be photographed or studied. The method used depends on what the print is on. For example, on metal things like a bullet casing, the person's sweat and oils might mix in a way that either helps show the print better or makes it harder to see—or it might only leave a small, incomplete part of the print. This makes it tricky to get a clear, usable image every time.

ISSUES WITH FINGERPRINT DATABASES:

New technology has made the Automated Fingerprint Identification System (AFIS) very common in police work. AFIS is a computer system that quickly searches huge databases of fingerprints to find possible matches for a print left at a crime scene. It works by using special algorithms (computer programs) that look for similarities between the crime scene print and prints already stored in the system. This has made identifying suspects much faster and easier. However, AFIS is not perfect and can still make mistakes. The computer might suggest wrong matches (called false positives), especially when the print from the crime scene is blurry, partial, or low quality.

Another problem comes from human errors. If someone types in the wrong information when adding fingerprints to the database, or if a person's records get mixed up or poorly scanned, the system could wrongly link an innocent person to a crime. Even though AFIS is a powerful tool,

these issues mean police and experts still need to carefully check any suggested matches by hand to avoid unfair or incorrect conclusions.

THEFT AND HACKING OF FINGERPRINT DATA:

Modern technology has raised a new concern regarding fingerprint evidence: the risk of fingerprint theft and hacking. Advanced tools enable cybercriminals to extract fingerprints from common surfaces or to breach databases containing biometric information. Once stolen, fingerprints can be duplicated to implicate someone falsely.

This risk highlights the ongoing uncertainty surrounding fingerprint evidence, particularly when it's unclear whether prints at a crime scene were intentionally placed, accidentally deposited, or intentionally left.[30]

EVIDENTIARY VALUE OF FINGERPRINT UNDER INDIAN CRIMINAL JUSTICE SYSTEM:

To begin with admissibility of forensic evidence, it is very essential to know who is an expert also what is his role? To what extent his opinion is taken into account while deciding a case. A witness is a person who is required to state the facts which he/ she has witness and not to give his inference regarding the same. The inference from the statement is made out by the Court, which is a judicial task.

INDIAN LAW ON FORENSIC EVIDENCE AND EXPERT EVIDENCE:

SECTION 45 of Indian Evidence Act – Following are the requirements of this section:

The foremost requirement of the expert opinion is that a matter is of such a nature that it is beyond the know-how of a lay man. The matter involves such medical issue or science which is outside the knowledge of the Court. The person giving an opinion must have specialization in that very field. The evidence must be based on reliable principles. The opinion of the expert is not circumstantial but corroborative that means that the opinion is not conclusive and it is advisory in nature.

ADMISSIBILITY OF FINGER PRINTS IN INDIAN COURT:

Fingerprints play a very important role in criminal cases. They help police collect evidence from the crime scene. After proper examination by experts, this evidence can be presented in

[30] https://www.cronisraelsandstark.com/fingerprint-weaknesses

court. But can a person be convicted (found guilty) based only on fingerprint evidence? What happens if there is no other supporting proof (i.e., the fingerprint evidence is uncorroborated it stands alone)? What is the real value (probative value) of an expert's opinion on fingerprints? The court can trust the fingerprint expert's opinion only if the expert clearly proves that: Certain prints are different from others, or The prints match exactly. When deciding, the court must carefully check two main things:

a) Whether the questioned mark (from the crime scene) is really similar to the known fingerprint of the accused.
b) Whether it is possible for two different people to have fingerprints that match in as many points of similarity as the expert has shown.

The big legal question — "Can someone be convicted solely on fingerprint evidence?" — was first seriously discussed in Indian courts through important case laws. Fingerprints collected from the crime scene (or from a victim) can strongly help decide whether to convict or acquit (free) the accused. In this process, the investigating police officer has a huge responsibility: Right from the moment the crime is reported, To properly collecting, preserving, and sending the fingerprints for examination.

In court, fingerprint evidence is treated as an "exact science" (very reliable and precise). In the important case In Re Govinda Reddy (and similar rulings), the court clearly said: "The science of comparing fingerprints has now reached a very high level of accuracy and exactness. It is possible to compare fingerprints reliably — but only if: The prints are clear enough, and Good enlarged photographs are available. With the help of a good magnifying glass, and especially when photos of the crime-scene print (latent) and the suspect's print (known) are placed side by side, identifying whether they match is not difficult."

In short: Fingerprint evidence is very strong and scientific, but courts are careful. They usually do not convict someone based only on fingerprints unless the match is perfect, the expert's opinion is clear and trustworthy, and there are no serious doubts about how the prints were collected or handled.

GUIDELINES ISSUED BY THE SUPREME COURT AND THE HIGH COURT IN RESPECT OF THE FINGERPRINTING:

When a court needs to compare fingerprints or handwriting, it should always take help from a qualified expert. Relying only on the judge's own observation can be risky and may lead to wrong decisions. Comparing two fingerprints is not something that can be done just by looking quickly or casually. It requires careful, expert examination. It is legally clear that asking a

person to give their fingerprint (or thumb impression) does not count as forcing them to give personal testimony against themselves. Under Section 73 of the Indian Evidence Act, an expert's opinion on handwriting or fingerprint comparison is considered valuable evidence. It helps the court make a better decision. If the victim's family believes the police investigation was careless, improper, or done by incompetent officers (especially regarding fingerprint collection or handling), they can file a complaint with the Sessions Judge.

Several High Courts (for example, Karnataka High Court and Madras High Court) have given clear guidelines on how fingerprint evidence should be collected, preserved, and presented in court. These guidelines are very important. They help make sure that fingerprint evidence is collected properly and can be accepted (admitted) as valid evidence in court — but only if everyone follows the rules strictly. In short: Fingerprint evidence is strong only when collected and examined correctly by experts, following proper guidelines. Courts should not take shortcuts.

CRITICAL ASPECT OF FINGERPRINT EVIDENCE IN INDIA:

Fingerprint evidence in India has several important limitations:

The AFIS (Automated Fingerprint Identification System) is a computerized tool that stores and matches fingerprints. However, it is not available everywhere. Many police stations and local forces do not have access to this technology. Setting up AFIS is very expensive. Because of the high cost, only a limited number of machines have been installed, and they are not present at every police or administrative level.

Fingerprints must be carefully preserved. If investigators do not handle or store them properly, the prints can get damaged, altered, or spoiled, making them unreliable. Fingerprints can be faked or imitated. Someone (even police or others) could create a fake print or copy parts of a real fingerprint to wrongly blame an innocent person.

Fingerprints can also be misused through fraud: In civil cases (for example): A relative might take a dead person's fingerprint and put it on a "life certificate" to keep collecting the deceased person's pension illegally. In criminal cases (for example): After committing a murder with a gun or knife, the killer might place the weapon in the victim's hand (or someone else's hand) to leave fake fingerprints and mislead the investigation. Because of these problems, fingerprints can sometimes be "planted" to frame someone. Courts must be very careful and examine

fingerprint evidence closely before using it to convict anyone. It should never be the only proof in a case.[31]

CHAPTER - IV

CONCLUSION:

The fingerprint analysis is a powerful tool in forensic identification, its reliability hinges on several critical factors. These include careful handling of evidence to prevent contamination, expert analysis by trained professionals, and an awareness of potential pitfalls like partial prints or database mismatches. By acknowledging these limitations and leveraging advancements in technology, such as automated identification systems and AI-enhanced matching, fingerprint analysis can continue to be a trusted method in investigations. Ultimately, a balanced approach combining human expertise with technological support ensures the integrity and reliability of fingerprint evidence in legal proceedings.

SUGGESTIONS:

The objective of the Criminal Justice System of India is not only to punish the wrongdoer or the perpetrator of the crime but also to prevent the occurrence of the crime. Such parameters can be fulfilled not only with the assistance of the Investigating Officers, police, courts, lawyers but when several techniques are given evidentiary value these, techniques which can be also termed as the scientific techniques like the Fingerprints in the elimination of the crime. Though, the use of scientific techniques like Fingerprints are not new, but reliability of these techniques depends upon the forensic experts.

Conduct Meta-Analyses: Aggregate data from 13+ published experiments (e.g., via systematic reviews in journals like Forensic Science International) to quantify error rates across examiner experience levels, focusing on metrics like inter-examiner agreement (kappa scores >0.8 indicate strong reliability). Factor-Specific Experiments: Use factorial designs in lab settings (e.g., via code execution tools like Python's SciPy for statistical modeling) to vary print quality (e.g., minutiae count <12) and substrate type, measuring accuracy via ROC curves. Bias Audits: Implement sequential unmasking protocols in mock cases, tracking error rates pre- and post-exposure to contextual info, and analyze via ANOVA to quantify bias magnitude.

Case Law Database Review: Query platforms like Manupatra or SCC Online for 50+

[31] https://articles.manupatra.com/article-details/Evidentiary-value-of-Fingerprints-in-Indian-Criminal-Justice-System

judgments post-2010 citing Section 45 and "fingerprint," coding for admission rates (target >90%) and reversal instances due to methodological flaws. Comparative Legal Analysis: Contrast Indian rulings with Daubert/Frye standards in the US via cross-jurisdictional studies, highlighting how Section 45's expert deference bolsters probative value. Empirical Court Impact Study: Survey 20-30 criminal cases (e.g., via anonymized judgments) to quantify conviction correlations with fingerprint evidence, using logistic regression to assess "high probative" thresholds.

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