



The Indian Journal for Research in Law and Management

Open Access Law Journal – Copyright © 2026

Editor-in-Chief – Dr. Muktai Deb Chavan; Publisher – Alden Vas; ISSN: 2583-9896

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IDENTIFICATION BY FINGERPRINTS AND FOOTPRINTS

~ *Utkarsh Kumar*

INTRODUCTION

Among all the disciplines that constitute the vast architecture of forensic science, the identification of individuals through friction ridge impressions fingerprints and footprints occupies a position of singular importance. It is at once the oldest and the most ubiquitous technique of personal identification in criminal investigation, relied upon by police and courts across every continent for over a century. Yet, behind the apparent simplicity of pressing an inked finger to a card lies a rich and complex science that intersects biology, mathematics, law, and technology.

Forensic identification is the process by which a forensic expert establishes, through scientific analysis, the identity of a person, object, or substance relevant to a legal proceeding. Within this domain, the study of dermatoglyphics the science of the ridge patterns on fingers, palms, and soles provides what is widely regarded as the most reliable biometric identifier known to science. The uniqueness and permanence of fingerprints have elevated them to the status of the gold standard of personal identification in both civil and criminal contexts.

This project undertakes a comprehensive study of fingerprint and footprint identification as a subject of forensic biology and forensic identification. It traces the biological foundations of friction ridges, the history of fingerprint science with particular attention to India's foundational contribution through the Henry Classification System (The [Henry Classification System](#) was developed in India and implemented in most English-speaking countries) and the pioneering work of Dr. Shreenivas of Patna Medical College Hospital, the methodology of fingerprint collection and analysis, the evidentiary framework governing fingerprint and footprint evidence in Indian law, and the emerging challenges posed by digital forensics and AFIS technology.

A fingerprint is an impression left by the friction ridges of a human finger. The recovery of partial fingerprints from a crime scene is an important method of forensic science. Moisture and grease on a finger result in fingerprints on surfaces such as glass or metal. Deliberate impressions of entire fingerprints can be obtained by ink or other substances transferred from the peaks of friction ridges on the skin to a smooth surface such as paper. Fingerprint records normally contain impressions from the pad on the last joint of fingers and thumbs, though fingerprint cards also typically record portions of lower joint areas of the fingers.

Human fingerprints are detailed, unique, difficult to alter, and durable over the life of an individual, making them suitable as long-term markers of human identity. They may be employed by police or other authorities to identify individuals who wish to conceal their identity, or to identify people who are incapacitated or dead and thus unable to identify themselves, as in the aftermath of a natural disaster.

THE SCIENCE OF FINGERPRINTS BIOLOGICAL FOUNDATIONS

A fingerprint is an impression left by the friction ridges of a human finger on a surface. The friction ridges are raised portions of the epidermis on the digits, palms, and soles, composed of one or more connected ridge units of friction ridge skin. These ridges are sometimes called “epidermal ridges,” caused by the interface between the dermal papillae of the dermis and the interpapillary (rete) pegs of the epidermis.

A. Formation of Friction Ridges

Friction ridges begin to form during the 13th week of fetal development. Ledge-like formations appear at the base of the epidermis beside the dermis, and cells along these ledges begin to proliferate rapidly, forming primary and secondary ridges. These act as templates for the outer layer of skin to produce the visible friction ridges. The precise configuration of ridges on any given finger is determined by a complex interaction of genetic and environmental factors, including the unique micro-environment surrounding each developing digit in the amniotic fluid.

The composition of fingerprint residue is approximately 95–99% water, with organic constituents (amino acids, proteins, glucose, fatty acids, urea, pyruvate) and inorganic ions (chloride, sodium, potassium, iron). Contaminants such as cosmetics, drugs, and food residues

may also appear in fingerprint deposits, making them chemically informative beyond mere pattern identification.

B. The Three Fundamental Properties of Fingerprints

The forensic use of fingerprints rests upon three scientifically established and legally recognised propositions:

1. **Permanence:** Friction ridges form during fetal development and remain essentially unchanged throughout the individual's life until decomposition after death. Superficial injuries to the skin (such as cuts or abrasions) that damage only the epidermis result in the regeneration of the same ridge pattern. Only deep injuries destroying the dermis can alter the pattern permanently.
2. **Uniqueness:** No two individuals not even identical (monozygotic) twins have been found to possess fingerprints that are identical in all their minute details. Although monozygotic twins share the same DNA and exhibit similar overall fingerprint patterns, the precise arrangement of ridge details (minutiae) differs. This uniqueness has never been disproved in over a century of scientific study.
3. **Classifiability:** Fingerprint patterns are susceptible to systematic classification into discrete categories based on their general ridge configuration, enabling the organisation of large repositories and the efficient retrieval of records for comparison.

C. Genetics of Dermatoglyphics

Consensus within the scientific community holds that fingerprint patterns are hereditary. Research using monozygotic twins demonstrates very high pattern similarity (though not identity), while dizygotic twins show considerably less. Significant heritability has been identified for twelve dermatoglyphic characteristics. Total ridge count is believed to have a polygenic mode of inheritance. Specific genes, including ADAMTS9-AS2 on chromosome 3p14.1 (influencing whorl patterns) and EVI1 (affecting limb and digit formation), have been implicated in fingerprint pattern formation. In 2023, researchers identified WNT, BMP, and EDAR signalling pathways as regulators of primary ridge formation, establishing a Turing reaction-diffusion system as the biological basis of ridge development.

HISTORICAL DEVELOPMENT OF FINGERPRINT SCIENCE

The history of fingerprint identification is one of the most fascinating narratives in the history of science, spanning from ancient civilisations to the digital age. It is also a story of intellectual appropriation, colonial injustice, and belated recognition.

A. Ancient and Pre-Scientific Use

The earliest known use of fingerprints as a form of identification predates modern science by millennia. In Babylon (c. 1800 BCE), fingerprints were impressed in clay tablets as signatures for business transactions. In ancient China and Japan, thumb prints were used to authenticate documents and seal pottery. The Mughal Emperor Jahangir's administrative records contain references to finger impressions as authenticating marks. These practices, while not based on a scientific understanding of ridge uniqueness, reflect an intuitive recognition of the individuality of fingerprints.

B. The Scientific Foundations (1684–1892)

The first scientific description of fingerprint ridge patterns was made by Dr. Nehemiah Grew of England in 1684, who described the pores and ridges of the human hand. Marcello Malpighi, an Italian anatomist, documented ridges and loops in 1686. The first systematic study specifically noting the uniqueness and persistence of fingerprint patterns was conducted by Johannes Evangelist Purkinje, a Czech physiologist, who in 1823 described nine principal fingerprint pattern types in his doctoral thesis.

Sir William James Herschel, British Chief Magistrate of the Hooghly district of Bengal, made the decisive empirical breakthrough. From 1858, Herschel began using handprints and, later, fingerprints to authenticate documents and identify persons in India. By 1877, he had formally instituted fingerprints as a means of identification in his district, observing over twenty years that fingerprints did not change with age. His observations provided the first large-scale empirical evidence of permanence.

Simultaneously, Dr. Henry Faulds, a Scottish physician working in Tokyo, published a landmark letter in the journal *Nature* in 1880, proposing that fingerprints found at crime scenes could be used to identify criminals. He also developed the first ink method of recording fingerprints. Faulds corresponded with Charles Darwin, who forwarded his work to his cousin Francis Galton.

Sir Francis Galton conducted the most comprehensive scientific study of fingerprints of the 19th century, published in his 1892 book *Finger Prints*. He statistically demonstrated the uniqueness of fingerprints, estimated the probability of two individuals sharing identical prints at 1 in 64 billion, and developed the first systematic approach to their classification based on three primary pattern types: arches, loops, and whorls. Galton's identification points (later called 'minutiae') ridge endings, bifurcations, and short ridges became the foundation of all subsequent fingerprint comparison methodology.

C. Anthropometry and the Transition to Fingerprints

Before fingerprints were adopted, the Bertillon system of anthropometry (developed by Alphonse Bertillon of France, 1879) was the principal method of criminal identification. It relied on eleven body measurements skull dimensions, arm length, foot length, and similar measurements to create a unique biometric profile. While ingenious, the Bertillon system was expensive, time-consuming, and susceptible to measurement error. The case of William West and William McHenry in the United States in 1903 two individuals with virtually identical Bertillon measurements but different fingerprints decisively demonstrated the Bertillon system's inadequacy and precipitated its replacement by fingerprint identification.

THE HENRY CLASSIFICATION SYSTEM INDIA'S UNACKNOWLEDGED CONTRIBUTION

CLASSIFICATION OF FINGERPRINTS PATTERNS AND SUB-TYPES

The Henry Classification System recognises three primary fingerprint patterns, which together encompass all possible ridge configurations. Understanding this taxonomy is foundational to forensic fingerprint work.

A. Primary Pattern Types

1. Arches (approximately 5% of all fingerprints)

Arches are the simplest fingerprint pattern. The ridges enter from one side of the finger and flow across the finger in a wave, rising in the centre, and exit on the other side. Arches contain no deltas (triangular formations). There are two sub-types: (a) Plain Arches ridges flow from one side to the other with a gentle rise in the centre; and (b) Tented Arches ridges form a sharp angle or spike near the centre, or one or more ridges rise to form a tent-like shape. Arches are

the least common pattern and have the fewest minutiae points, making them the least useful for individualisation when found in isolation.

2. Loops (approximately 60–65% of all fingerprints)

Loops are the most common fingerprint pattern. They contain at least one ridge that enters from one side, curves back upon itself, and exits on the same side. Loops have one delta. Two sub-types are defined by the direction of the loop's tail: (a) Ulnar Loops the loop opens toward the ulna (little finger side of the hand); and (b) Radial Loops the loop opens toward the radius (thumb side of the hand). Ulnar loops are far more common. In the Henry Classification System, loops are assigned a numerical value of 0.

3. Whorls (approximately 30–35% of all fingerprints)

Whorls are circular or spiral ridge patterns with at least two deltas. They are the most complex primary pattern and are assigned numerical values in the Henry classification formula, driving the computation of the primary classification fraction. Sub-types of whorls include: (a) Plain Whorls ridges form a complete circuit around a central point; (b) Central Pocket Loop Whorls one or more ridges make a complete circuit but the innermost ridges do not form a whorl; (c) Double Loop Whorls two separate loop formations; (d) Accidental Whorls irregular patterns not conforming to any other category; and (e) Peacock's Eye Whorls.

B. Minutiae (Ridge Characteristics) The Second Level of Detail

Beyond the primary pattern classification, individual fingerprint identification rests on the comparison of minutiae the specific ridge characteristics first identified by Galton and later systematised. The most important minutiae for forensic comparison are:

- Ridge Ending: A single ridge abruptly terminates.
- Bifurcation (Fork): A single ridge divides into two ridges.
- Short Ridge (Island): An extremely short ridge that begins and ends within a short distance.
- Enclosure (Lake): A single ridge splits into two and then rejoins.
- Spur: A bifurcation with one short branch.
- Crossover (Bridge): A short ridge connecting two parallel ridges.

The number of minutiae points required for a positive identification has been the subject of significant international debate. Many countries historically required a minimum of 12–16

points of correspondence, though modern forensic standards (including those adopted by the International Association for Identification in 1973) move toward holistic assessment without a fixed numerical threshold.

C. Third-Level Detail Poroscopy and Edgeoscopy

Third-level fingerprint detail refers to features smaller than minutiae: specifically, the shape and position of sweat pores along the ridges (poroscopy) and the precise configuration of ridge edges (edgeoscopy). Poroscopy was introduced by Dr. Edmond Locard in 1912, who demonstrated that pores are permanent, immutable, and unique to each individual, making them a reliable identification tool when ridge patterns are insufficient. Edgeoscopy, introduced by C. Cherrill, examines the outline of ridges (smooth, jagged, or scalloped) as an additional level of identification detail. These techniques are particularly valuable when partial or degraded fingerprints are recovered.

TYPES OF FINGERPRINTS AT CRIME SCENES

Fingerprints encountered in forensic investigations are classified into three categories based on their physical nature and visibility:

A. Patent (Visible) Fingerprints

Patent prints are directly visible to the naked eye because they are formed when the finger is coated with a contrasting substance blood, grease, paint, oil, ink, or similar material and the coated finger touches a surface. They are recorded by photography without further processing. Patent prints in blood are among the most forensically significant, as they may reveal both the pattern and the presence of the victim's blood on the offender's hand.

B. Plastic (Moulded) Fingerprints

Plastic prints are three-dimensional impressions formed when the finger contacts a malleable surface that retains the impression soft wax, putty, grease, clay, tar, fresh paint, or similar substances. These impressions can be photographed and, in some cases, cast with dental plaster or silicone casting material for detailed three-dimensional preservation.

C. Latent Fingerprints

Latent prints are the most commonly encountered and forensically challenging category. They are invisible or near-invisible to the naked eye, left by the natural secretions of sweat and

sebaceous glands through the friction ridges. Latent prints require physical or chemical development for visualisation. They represent the vast majority of fingerprint evidence recovered from crime scenes and their detection and preservation require specialised expertise.

METHODS OF DETECTING LATENT FINGERPRINTS

A. Physical Methods

Powder Dusting is the most traditional and widely used method. Fine particles of powder black aluminium powder on light surfaces, white titanium dioxide or calcium carbonate on dark surfaces, fluorescent powders for complex backgrounds adhere to the oily and fatty residues of the fingerprint deposit. The resulting visible print is photographed and lifted using adhesive tape. Magnetic powders, applied using a magnetic brush (eliminating bristle marks), are used on non-metallic surfaces. Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM) are advanced physical methods providing nanoscale imaging of fingerprint features.

B. Chemical Methods

Ninhydrin (2,2-Dihydroxyindane-1,3-dione) reacts with amino acids in the sweat residue to form a purple-coloured compound known as Ruhemann's Purple. It is highly effective on porous surfaces such as paper and cardboard and is the most sensitive amino-acid-based reagent. DFO (1,8-Diazafluoren-9-one) produces an orange fluorescence under blue-green light and is more sensitive than ninhydrin on some substrates. Physical Developer (PD) is a silver nitrate-based solution that deposits metallic silver on the fatty residues, creating a highly durable grey print. It works even on surfaces wetted by water, making it invaluable in flood or rain-exposed crime scenes. Cyanoacrylate (Superglue) fuming vapours of ethyl cyanoacrylate polymerise on the fingerprint residues, forming a white, durable deposit that can then be enhanced by powder or fluorescent staining. It is the standard method for non-porous surfaces.

C. Optical/Luminescence Methods

Laser and alternate light sources (ALS) excite fluorescent compounds naturally present in fingerprint residue or introduced by fluorescent dyes (such as Rhodamine 6G, RAM, or Lumicyano), causing the print to fluoresce visibly against a dark background. These methods are particularly effective when powdering or chemical treatment would be inadequate due to a complex background surface.

D. Biological Methods

Immunogenic fingerprint detection uses antibodies raised against specific fingerprint biomarkers particularly drugs, their metabolites, or sex hormones to simultaneously visualise and characterise the print. This approach, combining identification with forensic profiling of the print's depositor, represents the cutting edge of fingerprint detection science.

DR. SHREENIVAS AND THE DERMATOGLYPHICS–E.V. METHOD: A PIONEER FROM PATNA

Among the contributions to fingerprint science made in India, the work of Dr. Shreenivas a physician at Patna Medical College Hospital deserves recognition in any comprehensive study of fingerprint identification, particularly given the local significance of this project.

A. Background and Context

Dr. Shreenivas served as Lecturer in Medicine and Officer-in-Charge of the Department of Cardiovascular Diseases at Medical College Hospital, Patna. He co-authored, with Saradindu Narayan Sinha, Senior Expert of the Finger Print Bureau, C.I.D., Bihar, Patna, a pioneering work titled “Personal Identification by the Dermatoglyphics and the E-V Methods.” This collaboration between a clinician and a fingerprint bureau expert is itself emblematic of the interdisciplinary nature of forensic identification science.

Government sanction for the publication of this work was granted by the Dy. Director of Health Services, (M) Bihar, through Letter No. IIM3-1-144/54-15828/H dated 17th June, 1954 confirming that the Government of Bihar had no objection to Civil Assistant Surgeon Dr. Shreenivas, Medical Registrar, Patna Medical College Hospital, publishing the Book on ‘Identifications by Finger Prints and E.V. Methods.’ The manuscript was formally approved on 21st June, 1954 and the copy forwarded to Dr. Shreenivas by the Superintendent of Patna Medical College Hospital.

B. The Dermatoglyphics Method

The term ‘dermatoglyphics’ (from the Greek: derma = skin; glyphe = carving) refers to the study of the ridge systems on the fingers, palms, and soles. Dr. Shreenivas’ work on dermatoglyphics for personal identification sought to apply the systematic study of ridge patterns to both forensic identification and clinical diagnosis recognising that dermatoglyphic patterns are associated not only with individual identity but also with certain chromosomal and systemic disorders. The clinical application of dermatoglyphics anticipated the later medical

use of ridge patterns in diagnosing conditions such as Down syndrome, Turner syndrome, and congenital heart disease.

C. The E-V (Edmond–Vucetich) Method

The E-V Method referenced in Dr. Shreenivas' work likely refers to the Vucetich System of fingerprint classification, developed by Juan Vucetich in Argentina in 1891–1892, which the Argentinian police officially adopted in 1896 predating the formal adoption of the Henry System in India. The Vucetich system uses four primary pattern types Arch (A), Internal Loop (I), External Loop (E), and Whorl (V) and a different mathematical formula from Henry. The study of both dermatoglyphics and the E-V method by Dr. Shreenivas reflects a rigorous comparative approach to fingerprint science that sought to synthesise different classification traditions for enhanced forensic utility. His work represents Patna's distinctive contribution to the scientific literature of fingerprint identification in post-independence India.

FOOTPRINTS AS EVIDENCE PODOSCOPY AND ITS FORENSIC VALUE

While fingerprints are the most studied and utilised form of friction ridge evidence, footprints constitute an equally significant and in some crime scenarios, more readily available form of personal identification evidence. The forensic study of footprints encompasses both bare footprints (podoscopy) and shoeprints (shoescopy).

A. Podoscopy The Science of Bare Footprint Identification

Podoscopy is the study and comparison of bare footprints for the purpose of personal identification. Just as fingerprints on the fingers, the plantar (sole) surface of the foot is covered with friction ridges that are unique to each individual, permanent throughout life, and classifiable by pattern type. The forensic principles applicable to fingerprints uniqueness, permanence, and classifiability apply with equal force to plantar impressions.

Bare footprints may be found at crime scenes as: (a) patent impressions in blood, oil, or other materials; (b) plastic impressions in soft soil, mud, sand, or snow; or (c) latent impressions on smooth hard floors. The detection, lifting, and comparison of such prints follows the same forensic methodology as fingerprint evidence. Footprints also provide additional biological information not available from fingerprints, including an estimate of the individual's height, gait, and walking pattern, and in some cases, sex determination based on plantar dimensions.

B. Shoescopy Shoeprint Evidence

Shoeprints are among the most frequently encountered impression evidence at crime scenes. A shoeprint preserves the unique combination of: (a) the pattern of the shoe's outsole (manufacturer's design); (b) the size of the shoe; and (c) acquired characteristics cuts, nicks, wear patterns, embedded debris unique to that particular shoe and capable of individualising it to the specific shoe (and, by inference, to its wearer). Class characteristics identify the shoe's make, model, and size; individual characteristics individualise the specific shoe. Shoeprints are developed and lifted using the same techniques as other impression evidence (photography, electrostatic lifting apparatus (ESLA), casting).

C. Forensic Gait Analysis

Modern forensic podoscopy extends to gait analysis the study of walking patterns. Each individual's gait (stride length, step width, foot angle, cadence) is distinctive and measurable from footprint evidence. Forensic gait analysis has been used in CCTV footage analysis and in the comparison of sequential footprints at crime scenes. It provides circumstantial evidence of an individual's identity even in the absence of a full footprint pattern suitable for minutiae comparison.

AUTOMATED FINGERPRINT IDENTIFICATION SYSTEM (AFIS) AND DIGITAL FORENSICS

The Henry Classification System, for all its elegance, was inherently limited by human capacity: searching a large fingerprint repository manually required considerable time and expertise, and was susceptible to human error. The development of Automated Fingerprint Identification Systems (AFIS) transformed fingerprint forensics from a manual, expert-dependent process to a high-speed, computerised operation.

A. How AFIS Works

AFIS systems digitise fingerprint images and use algorithmic processes to extract and encode minutiae points and their spatial relationships into a digital template. This template is then compared against all templates in the database using mathematical matching algorithms, generating a ranked list of candidate matches (a candidate list) for human expert review. Modern AFIS systems can search databases of hundreds of millions of fingerprint records in seconds. The world's largest AFIS the US FBI's Next Generation Identification (NGI) system holds over 150 million fingerprint records.

B. AFIS in India NCRB and State Systems

In India, the National Crime Records Bureau (NCRB) operates the National Automated Fingerprint Identification System (NAFIS), launched in 2020 and operational from 2022. NAFIS provides a centralised national fingerprint database linked to criminal records, enabling state police forces to search fingerprints recovered from crime scenes against a national repository. Each arrested person is assigned a unique ten-digit NAFIS ID. Prior to NAFIS, state-level AFIS systems operated independently, limiting inter-state case linkage. The integration of NAFIS with the Crime and Criminal Tracking Network and Systems (CCTNS) represents a significant advance in India's forensic infrastructure.

C. Latent Print Technology and AI

Artificial intelligence and deep learning algorithms are increasingly being applied to fingerprint analysis, particularly for partial, degraded, or distorted latent prints. Deep learning convolutional neural networks (CNNs) trained on large fingerprint databases have demonstrated accuracy in latent-to-rolled print matching that approaches or exceeds human expert performance in laboratory conditions. In 2023, a study published in *Science Advances* claimed that an AI system could match fingerprints from different fingers of the same person a challenge previously considered intractable by focusing on ridge curvature patterns near the centre of the fingerprint rather than on minutiae alone. This raises both forensic opportunities and evidentiary reliability concerns that courts have yet to fully address.

LEGAL FRAMEWORK FINGERPRINT AND FOOTPRINT EVIDENCE IN INDIA

The use of fingerprint and footprint evidence in Indian criminal proceedings is governed by a comprehensive legal framework spanning multiple statutes, constitutional provisions, and judicial precedents.

A. The Identification of Prisoners Act, 1920

The Identification of Prisoners Act, 1920 is the primary legislation governing the taking of fingerprints and measurements from convicted and arrested persons. Section 3 of the Act empowers a Magistrate or the Officer-in-Charge of a Police Station to direct the taking of measurements (including fingerprints and footprints) from any person who has been convicted of, or arrested in connection with, an offence punishable with rigorous imprisonment for one year or more. Section 5 provides for the destruction of fingerprint records if the person is acquitted or discharged and has no previous conviction. The Criminal Procedure

(Identification) Act, 2022 has substantially expanded and updated this framework, permitting the collection of a wider range of biological samples and biometric data.

B. The Criminal Procedure (Identification) Act, 2022

Enacted to replace the Identification of Prisoners Act, 1920, this Act significantly expands the permissible categories of biological and biometric data collectable from arrested and convicted persons. It permits collection of finger impressions, palm print impressions, footprint impressions, photographs, iris and retina scans, physical and biological samples, and behavioural attributes such as signatures and handwriting. Data may be stored for 75 years. The Act has been criticised by civil liberties scholars for its potential to enable mass biometric surveillance and for the breadth of its powers relative to the presumption of innocence.

C. The Indian Evidence Act, 1872 (now, Bharatiya Sakshya Adhiniyam, 2023)

Fingerprint evidence is admissible as expert evidence under Section 45 of the Indian Evidence Act, 1872 (IEA), which provides that when the court has to form an opinion on a point of foreign law, science, art, or as to the identity of handwriting or finger impressions, the opinions of persons especially skilled in such matters are relevant. The heading “finger impressions” was added to the original text of Section 45 in 1899 the very year the Henry Classification System was being presented internationally reflecting the immediate legal incorporation of fingerprint science.

Section 73 of the IEA further empowers the court to compare fingerprints itself or to direct any person to allow fingerprints to be taken for comparison. The expert opinion under Section 45 is a relevant fact but is not binding on the court; a court may accept or reject it based on its own assessment of the methodology and reasoning. Section 293 of the Code of Criminal Procedure (Cr.PC) permits the report of a government fingerprint expert to be admitted in evidence without the expert being physically present, subject to the accused’s right to summon the expert for cross-examination.

D. Constitutional Dimensions Articles 20(3) and 21

The compulsion to provide fingerprints raises a constitutional question: whether it amounts to compelling a person to be a witness against himself under Article 20(3) of the Constitution, which guarantees the right against self-incrimination. The Supreme Court of India comprehensively addressed this issue in *Selvi v. State of Karnataka* (2010) AIR 2010 SC 1974,

holding that while testimonial self-incrimination is constitutionally protected, the compelled extraction of physical evidence (including fingerprints and blood samples) does not violate Article 20(3) because fingerprints are not 'testimonial' they do not involve the accused communicating information based on personal knowledge. This distinction, drawn from the earlier judgment in *State of Bombay v. Kathi Kalu Oghad* (1961), remains the governing constitutional principle.

CONCLUSION

The identification of individuals through their fingerprints and footprints is among the oldest, most scientifically validated, and most legally entrenched disciplines of forensic science. From the intuitive use of thumb impressions in ancient Babylon to the mathematical elegance of the Henry Classification System, from the first fingerprint bureau established in colonial Calcutta to the artificial intelligence systems of the 21st century, the science of friction ridge identification has undergone continuous and profound development.

This project has endeavoured to survey this science comprehensively from its biological foundations in the formation of friction ridges during fetal development, through the historical narrative that must finally acknowledge the primary intellectual contributions of Qazi Azizul Haque and Hem Chandra Bose to the classification system named after their supervisor Sir Edward Henry, to the methodological sophistication of latent print detection, and the legal architecture that governs fingerprint and footprint evidence in India.

The work of Dr. Shreenivas at Patna Medical College Hospital, documented in the 1954 government correspondence permitting publication of his book on personal identification through dermatoglyphics and E-V methods, stands as a testament to Patna's own contribution to this global scientific tradition. His collaboration with Saradindu Narayan Sinha of the Bihar CID Fingerprint Bureau a physician and a fingerprint expert working together models the interdisciplinary approach that forensic identification science has always required.

The challenges that remain the absence of uniform standards, the risk of contextual bias, the constitutional tensions raised by mass biometric collection, and the emerging frontier of AI-assisted analysis ensure that fingerprint science will continue to require the critical engagement of lawyers, scientists, and policymakers. The fundamental proposition, however, established over more than a century of scientific work and judicial application, remains: that the friction ridges of the human hand and foot, in their uniqueness, permanence, and classifiability, constitute one of the most reliable and enduring foundations of personal identification that science has discovered.