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How Forensic Evidence Helps Solve Crimes

DHARA BHAVANA*

ABSTRACT

Forensic science plays a significant role in modern criminal investigations by applying scientific methods to the identification, collection, preservation and analysis of evidence. Forensic evidence assists investigating agencies in reconstructing crime scenes, identifying suspects, establishing connections between individuals and criminal activities, and presenting scientific findings before courts of law. Evidence such as DNA profiles, fingerprints, bloodstain patterns and digital records can contribute to the investigation and prosecution of criminal offences. However, the reliability of forensic evidence depends on proper collection procedures, preservation of evidentiary integrity, scientifically valid examination techniques and impartial interpretation of results. Contamination, inadequate laboratory facilities, incorrect interpretation and weaknesses in maintaining the chain of custody may affect the evidentiary value of forensic findings. In India, forensic evidence must also be evaluated within the framework of applicable criminal procedure and evidence law, particularly the Bharatiya Sakshya Adhiniyam, 2023. This article examines the importance of forensic evidence in criminal investigations, its major forms, its evidentiary value, and the legal and practical challenges associated with its use. It argues that forensic science can strengthen the administration of criminal justice when supported by scientific reliability, procedural safeguards, expert accountability and judicial scrutiny.

Keywords: Forensic Science, Criminal Investigation, Criminal Justice

I. INTRODUCTION

The modern criminal justice system relies heavily on objective facts to establish the truth beyond reasonable doubt. Historically, criminal prosecutions depended largely on eyewitness testimony and circumstantial narrative-building. However, the limits of human perception, the decay of memory and subjective bias frequently introduced vulnerabilities into judicial proceedings. Forensic science bridges the gap between investigative hypothesis and objective proof by applying physical, chemical, biological and technological principles to legal inquiries. In contemporary jurisprudence, forensic evidence serves as a critical instrument for establishing the *corpus delicti*, linking offenders to crime scenes, exonerating the wrongfully accused and reconstructing the sequence of events surrounding a crime. From minute biological traces to

* Author is a Student at Aurora Deemed to be University, Hyderabad, Telangana, India.

complex digital footprints left across interconnected networks, forensic artefacts provide impartial insight into the facts in issue.

A. Evolution of forensic science in criminal justice

The application of scientific methods to crime investigation has evolved from rudimentary observation to sophisticated molecular and digital diagnostics. Early developments focused primarily on anatomical examination and fingerprint classification systems, such as the Henry Classification System introduced in the late nineteenth century. Over the past century, advances in genetics, mass spectrometry and computing have transformed forensic science into a multidisciplinary field encompassing DNA technology, digital forensics, chemical toxicology and ballistics.

i. Transition from witness testimony to scientific proof

The shift from reliance on testimony to scientific confirmation represents one of the most profound developments in criminal law. Eyewitness identification, while traditionally persuasive, has been shown to be susceptible to cognitive error, environmental limitations and subconscious bias. Forensic evidence provides an empirical anchor that withstands the passage of time, offering trial courts verifiable indicators of presence, contact and action.

II. MAJOR FORMS OF FORENSIC EVIDENCE

Forensic evidence spans biological, physical, chemical and digital disciplines. Each category relies on distinct laboratory methods and serves specialised diagnostic functions within the investigative process.

A. Biological evidence

Biological evidence includes blood, epithelial cells, hair roots, semen, saliva and bone tissue. Deoxyribonucleic acid (DNA) profiling is the benchmark for biological identification, enabling forensic geneticists to match crime-scene samples with suspect profiles with a very high degree of statistical confidence.

i. DNA profiling and serology

DNA profiling examines short tandem repeat (STR) loci in human nucleated cells to generate highly discriminating genetic profiles. Serological examinations assist in locating and preliminarily identifying biological fluids before extraction. In inquiries into violent crime, DNA evidence can firmly connect an individual to a victim or a location, or definitively exclude an innocent suspect.

B. Impression and pattern evidence

Impression evidence arises when an object leaves physical marks on a surface. Friction ridge analysis (of fingerprints and palm prints) remains a primary tool because of the premises of permanence and uniqueness. Other forms include tyre tread impressions, footwear marks, tool marks and bite marks.

C. Physical and chemical evidence

Chemical analysis focuses on illicit substances, toxicological screening, fire accelerants, explosives and gunshot residue (GSR). Spectrophotometry and gas chromatography-mass spectrometry (GC-MS) allow forensic chemists to detect minute traces of compounds, identifying poisons in post-mortem tissue or chemical compositions in arson investigations.

D. Digital and electronic evidence

The expansion of digital communication has made digital forensics an essential field. It encompasses the extraction and analysis of data stored on computers, smartphones, cloud servers and Internet of Things (IoT) devices. Electronic evidence provides crucial timeline data, location records (GPS and cell-tower logs) and communication trails.

Category	Primary artefacts	Analytical methods
Biological evidence	Blood, semen, saliva, hair roots, bone fragments	STR typing, mitochondrial DNA, serological testing
Impression evidence	Fingerprints, footwear prints, tyre marks, tool marks	Automated Fingerprint Identification System (AFIS), comparison microscopy
Chemical / toxicological	Gunshot residue, poisons, narcotics, accelerants	GC-MS, atomic absorption spectroscopy, HPLC
Digital evidence	Smartphones, hard drives, server logs, cloud storage	Bit-stream imaging, hash value verification (MD5/SHA-256)

Table 1: Key categories of forensic evidence and their primary applications

III. ROLE OF FORENSIC EVIDENCE IN SOLVING CRIMES

Forensic evidence supports criminal investigations at multiple stages, transforming physical items gathered at a crime scene into actionable intelligence and into evidentiary material admissible in judicial proceedings.

A. Crime scene reconstruction

Reconstruction involves analysing the physical layout of the scene, the distribution of bloodstain patterns, the trajectories of projectiles and the placement of objects in order to determine the sequence of events. Bloodstain pattern analysis (BPA), for example, provides

insight into the force applied, the positions of the victim and the perpetrator, and the direction of impacts.

B. Suspect identification and linkage

Applying Locard's exchange principle, which holds that every contact leaves a trace, forensic analysts identify physical connections between suspects, victims and crime scenes. Microscopic fibres, latent fingerprints or biological fluids can establish physical presence and contact.

C. Exoneration of the innocent

The impact of forensic science is equally substantial in preventing wrongful convictions. Post-conviction DNA testing has exonerated numerous individuals who had been wrongfully convicted on the basis of erroneous eyewitness accounts or coerced confessions, demonstrating the importance of scientific objectivity.

IV. LEGAL FRAMEWORK IN INDIA: THE BHARATIYA SAKSHYA ADHINIYAM, 2023

In India, the admissibility and evaluation of forensic findings fall within the statutory frameworks of criminal procedure and evidence. With the enactment of the Bharatiya Sakshya Adhiniyam, 2023 (BSA), which repealed and replaced the Indian Evidence Act, 1872,¹ the law governing expert opinion and electronic records has been modernised.

A. Statutory provisions for expert evidence

Under Section 39 of the Bharatiya Sakshya Adhiniyam, 2023,² which corresponds to Section 45 of the former Indian Evidence Act,³ the opinions of experts are relevant facts when the court has to form an opinion upon a point of foreign law or of science or art, or any other field, or as to the identity of handwriting or finger impressions.⁴ Expert testimony functions as advisory evidence: it is intended to aid the judge in interpreting technical and scientific data.

B. Electronic and digital records framework

The Bharatiya Sakshya Adhiniyam, 2023 gives expanded statutory recognition to digital and electronic evidence under Sections 61, 62 and 63.⁵ Primary electronic evidence includes the original digital media, while secondary electronic evidence must be accompanied by a

¹ The Bharatiya Sakshya Adhiniyam, 2023, No. 47, Acts of Parliament, 2023, § 170(1) (India).

² *Id.* § 39(1).

³ The Indian Evidence Act, 1872, No. 1, Acts of Parliament, 1872, § 45 (India) (repealed 2024).

⁴ *Cf. State of Maharashtra v. Damu*, (2000) 6 SCC 269 (India) (declining to act on the opinion of an Assistant State Examiner of Documents where the expert was not examined and it was not shown that his office fell within Section 293 of the Code of Criminal Procedure, 1973).

⁵ Bharatiya Sakshya Adhiniyam, 2023, §§ 61–63.

certificate under Section 63(4), in the form set out in the Schedule, which records hash values in order to ensure integrity and guard against tampering during extraction.

C. Constitutional safeguards and judicial scrutiny

Forensic procedures must comply with constitutional guarantees, particularly the privilege against self-incrimination in Article 20(3) of the Constitution of India.⁶ In *Selvi v. State of Karnataka*, the Supreme Court of India held that the involuntary administration of narco-analysis, polygraph examination and the Brain Electrical Activation Profile (BEAP) test violates Article 20(3) and the right to personal liberty, including mental privacy, under Article 21.⁷ Fingerprints, biological samples and specimen handwriting, however, remain obtainable under statutory authorisation, since material used only for identification or comparison does not by itself incriminate the accused and so falls outside Article 20(3).⁸

V. CHALLENGES AND VULNERABILITIES IN FORENSIC EVIDENCE

While forensic science enhances investigative accuracy, its application is vulnerable to human error, environmental factors and administrative constraints. The evidentiary value of a forensic report depends on the integrity of the underlying procedures.

A. Chain of custody and contamination

Maintaining a strict chain of custody is essential to establishing the integrity of evidence. Every person who handles, transports, analyses or stores an exhibit must record the date, time and purpose of custody. Any break in this chain, or improper packaging leading to degradation or cross-contamination of a sample, can invalidate forensic findings under judicial scrutiny.

B. Laboratory infrastructure and standardisation

Inadequate infrastructure, the lack of standard operating procedures (SOPs), backlogs of pending forensic examinations and insufficient laboratory accreditation all delay the delivery of expert reports. Scientific reliability requires rigorous proficiency testing and standardised validation protocols across forensic facilities.⁹

⁶ INDIA CONST. art. 20, cl. 3.

⁷ *Selvi v. State of Karnataka*, (2010) 7 SCC 263 (India).

⁸ *Id.*

⁹ NATIONAL RESEARCH COUNCIL, STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD (2009) (Recommendations 7–8), <https://doi.org/10.17226/12589>.

C. Cognitive bias and expert accountability

Forensic examiners can be subject to contextual and confirmation bias, particularly when they are exposed to investigative details unrelated to the scientific testing.¹⁰ Blind analysis procedures and rigorous peer review within laboratories are necessary to safeguard the objectivity of experts.

VI. CONCLUSION AND RECOMMENDATIONS

Forensic evidence is an indispensable component of the modern criminal justice system, turning scientific methods into tools of justice. When properly collected, systematically preserved and rigorously analysed, forensic findings provide reliable guidance for establishing guilt or innocence. Scientific findings should not, however, be accepted without proper judicial scrutiny. The ultimate objective is to maintain an equitable balance between innovative investigative methods and statutory procedural safeguards.

To maximise the reliability of forensic science under the Bharatiya Sakshya Adhiniyam, 2023, the following recommendations are offered:

- Standardised chain-of-custody protocols: implement digital chain-of-custody tracking, using cryptographic hash logs, from the initial scene of crime to final laboratory storage.
- Infrastructure expansion and accreditation: upgrade regional and state forensic science laboratories to meet national quality standards, with mandatory accreditation and regular blind proficiency testing.
- Interdisciplinary training: provide systematic training for police officers, judicial officers and legal practitioners in proper evidence handling, digital preservation and the interpretation of forensic reports.
- Institutional examiner blindness: enforce double-blind analysis procedures within forensic science facilities to minimise cognitive bias in subjective pattern comparison.

¹⁰ NATIONAL RESEARCH COUNCIL, *supra* note 9 (Recommendation 5).