FORENSIC SCIENCE: JOURNEY FROM CRIME SCENE TO COURTROOM

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ABSTRACT

This paper expands on the core processes and legal principles that govern forensic science in India, tracing the lifecycle of physical and digital evidence from the crime scene to courtroom presentation. It situates forensic practice within procedural safeguards, statutory provisions and recent judicial guidance, and analyses how investigation-stage decisions influence admissibility and probative value at trial. Special emphasis is placed on chain-of-custody, sample collection and preservation, laboratory quality assurance, expert reporting, and the evolving jurisprudence, particularly recent Supreme Court guidance standardising DNA-handling procedures. Recommendations aim to strengthen institutional capacity, standard operating procedures, and legal clarity so that scientific evidence remains reliable and defensible in criminal adjudication.

Keywords: forensic science; chain of custody; DNA evidence; crime scene management; expert testimony

Introduction

Forensic science converts physical facts into information that helps reconstruct events, attribute actions, and assist courts to reach reasoned conclusions. The modern criminal investigation relies heavily on scientific disciplines, from traditional forensic pathology and fingerprints to DNA, toxicology, ballistics and digital forensics. However, the mere availability of scientific techniques does not guarantee justice. The reliability of forensic evidence depends upon rigorous protocols applied at every step: the initial crime-scene response, collection, packaging, chain-of-custody maintenance, laboratory analysis, reporting, and finally, how the evidence and expert testimony are evaluated by courts. This paper explains each stage in depth and anchors the discussion in Indian procedural law and recent judicial pronouncements that seek to standardise forensic practice.

Methodology

The paper follows a doctrinal and comparative-descriptive methodology. Primary legal materials (statutes, rules, and judicial pronouncements) are synthesised with international technical guidance from institutions such as UNODC (UNODC, Crime Scene Handbook) and INTERPOL (INTERPOL, 2021), and with government policy on forensic infrastructure and accreditation. The aim is practical: to translate technical standards into legally robust operating procedures for investigators, forensic practitioners and lawyers.

1. Forensic disciplines: an overview

Forensic practice is multi-disciplinary. The investigator should understand the core capabilities and limitations of each field so that evidence collection is tailored to the investigative question. Major forensic disciplines include:

- Forensic pathology: establishes cause and manner of death, time since death and injury interpretation.
- Crime scene investigation (CSI): systematic documentation, photography, sketches, and primary evidence collection.
- Fingerprint and friction ridge analysis: identification through latent prints.

- DNA analysis and serology: human identification and source attribution using biological material.

- Toxicology: detection of drugs, alcohol, poisons and metabolites relevant to cause of death or impairment.

- Ballistics and firearms examination: linking projectiles and firearms, reconstructing shooting events.

- Questioned documents: handwriting, inks, paper and forgery analysis.

- Digital forensics: imaging and analysing data from computers, mobile devices, cloud services and IoT devices.

Each discipline has specific collection needs, laboratory requirements and interpretative frameworks; cross-disciplinary coordination is often necessary. This paper pays special attention to DNA and digital evidence because of their recent centrality in Indian litigation and the procedural challenges they raise.

2. Crime scene management

The crime scene is where the evidentiary clock starts. Effective crime-scene management protects perishable evidence and reduces contamination risk. Key operational principles include:

- Secure and control access: establish a perimeter, log all entries and exits, and preserve the scene until documentation and collection are complete.

- Safety and priorities: preserve life first; then protect evidence. Where necessary, first responders must prioritise victim/witness safety and medical needs while minimising disturbance to potential evidence.

- Systematic documentation: use high-resolution photography (including scales and orientation), videography, sketches with dimensions, and contemporaneous notes. Photograph before evidence is moved.

- Evidence triage: identify fragile or perishable items (biological fluids, latent prints,

electronics) and collect them first using discipline-specific methods (sterile swabs for biological samples, paper envelopes for suspected biological stains to avoid moisture buildup, Faraday/anti-static packaging for electronics).

- Use of PPE and contamination control: gloves, masks, shoe covers and single-use tools reduce transfer of DNA and other contaminants. Whenever possible, collect controls (negative controls from the scene) to detect environmental contamination.

Failure at the scene is often irreversible. Observational errors, inadequate documentation or sloppy packaging can permanently weaken or exclude otherwise probative scientific evidence.

3. Evidence collection, packaging and preservation

Evidence integrity depends on how items are collected and preserved. Practical guidance follows:

- Identification and labelling: every item should be assigned a unique identifier that links to the case/FIR number, item number, date/time and collector's identity.

- Packaging materials: porous materials (paper envelopes) are preferred for biological stains; sealed sterile containers and screw-cap tubes are used for liquids. Use tamper-evident seals where possible.

- Temperature and desiccation: biological material can degrade rapidly in heat and humidity. Where feasible, biological samples should be refrigerated and transported under cold chain conditions, or dried and stored with desiccants for stability.

- Chain-of-custody forms: every transfer should be logged with signatures, dates, times and reasons for transfer. This minimizes disputes about handling and supports admissibility.

- Digital devices: photograph devices in situ including power/state screens, capture network connections, isolate from networks (airplane mode or physical Faraday shielding), and, where practicable, clone storage media using write-blockers to preserve original data.

- Controls and blanks: especially in trace and DNA evidence, collection of environmental blanks and reagent controls enables laboratories to detect contamination introduced during collection.

Well-documented, standardised collection protocols protect evidence from challenge and enable reliable laboratory analysis.

4. Chain of custody and documentation

The chain of custody is more than an administrative form: it is the legal narrative that links a piece of evidence found at the scene to what is presented in court. The chain records who collected the item, how it was packaged, every person who handled it thereafter, and where it was stored. An unbroken, contemporaneous chain is essential to rebut any claim of tampering.

International guidance emphasises standardised unique identifiers, time-stamped transfer logs, signatures of individuals transferring and receiving items, and secure storage with access control. UNODC (UNODC, Crime Scene Handbook) and other international bodies provide operational checklists and templates that can be adapted by police services to ensure defensible custody practices. Using standard forms and an auditable trail reduces the risk that evidence will be excluded for doubts about its integrity. (Operational guidance on crime-scene awareness and chain-of-custody is summarised in UNODC (UNODC, Crime Scene Handbook) handbooks.)

5. Laboratory analysis and quality assurance

Forensic laboratories convert collected samples into interpretable data. Laboratory competence is a function of facilities, validated methods, trained staff, accreditation and quality management. Best practices include:

- Accreditation: internationally recognised standards such as ISO/IEC 17025 (ISO/IEC 17025) demonstrate that a laboratory operates competently and produces valid results. Accreditation requires documented quality manuals, method validation, proficiency testing, and internal audits.

- Standard operating procedures (SOPs): laboratories should have written SOPs for every analytical technique, detailing sample receipt, internal controls, instrument calibration,

data analysis and reporting.

- Contamination controls and blanks: cross-contamination between samples can generate false matches; negative and positive controls, reagent blanks and separation of workspaces mitigate these risks.

- Chain-of-custody integration: laboratories must not analyse items without verifying custody records; all receipt and disposal steps should be logged and linked to the case record.

- Proficiency testing and accreditation renewal: periodic blind proficiency tests assess analyst competence; external audits and inter-laboratory comparisons underpin reliability and public confidence.

The Government of India has been expanding forensic infrastructure (including the National Forensic Sciences University and central laboratories) and encouraging accreditation and standardisation to reduce pendency and improve reliability. (Government of India, Forensic Infrastructure Scheme)

6. Forensic reporting and expert testimony

Laboratory outputs should be communicated in a transparent, measured manner. Key principles for reporting and testimony are:

- Clarity about methods and limitations: reports must describe the analytical method, controls used, criteria for interpretation and statistical weight or limitations. Avoid overstated or categorical language where uncertainty exists.

- Opinion vs. fact: forensic results are often opinions based on scientific technique; under longstanding Indian law, expert opinions are admissible but not conclusive, they assist the court under Section 45 of the Indian Evidence Act. The court assesses the weight of expert evidence in light of methodology, validation and corroboration.

- Documentation for transparency: raw data, instrument output, chain-of-custody records and analyst notes should be preserved and made available for verification or cross-examination.

- Witness preparedness: experts should be able to explain their methods to a lay court, defend validation and error rates, and accept scrutiny during cross-examination.

An expert who explains uncertainty candidly and provides contextualised probabilistic statements increases the credibility of the evidence in adjudication.

7. Legal admissibility and Indian context

Indian courts treat forensic reports as opinion evidence that must be weighed against other material on record. The law balances the probative value of scientific evidence with constitutional protections, procedural fairness and reliability. Two doctrinal points deserve emphasis:

- Constitutional limits on involuntary testing: The Supreme Court in Selvi v. State of Karnataka (Selvi v. State of Karnataka, 2010) held that narco-analysis, polygraph and brain-mapping tests conducted without consent raise serious constitutional questions under Article 20(3) (protection against self-incrimination) and Article 21 (personal liberty and privacy). The ruling constrained investigative practices that intrude on bodily autonomy and human dignity, and remains a cornerstone of jurisprudence on scientific tests.

- Expert evidence as opinion: Section 45 of the Indian Evidence Act recognises opinions of persons with specialised skill in science or art as relevant, but it leaves the final opinion-making power with the court. Courts routinely consider the methodology, chain of custody and laboratory quality when assigning weight to forensic opinion.

Recent Supreme Court guidance in Kattavellai @ Devakar v. State of Tamil Nadu (Kattavellai @ Devakar v. State of Tamil Nadu, 2025) (2025) has been particularly consequential: the Court issued standardised procedural directions for the collection, preservation, transportation and processing of DNA and biological evidence, emphasising contemporaneous documentation, immediate packaging, timely submission to accredited laboratories and maintenance of chain-of-custody registers to avoid contamination and wrongful convictions. This judgment directs courts and law enforcement to adopt uniform protocols and enhances the probative value of DNA when conducted within these safeguards. The combined effect of these authorities is clear: forensic evidence is powerful but procedural rigor is mandatory, any lapses in collection

or custody can substantially undermine admissibility and weight.

8. Common pitfalls and case examples

Even well-established techniques may be undermined by operational lapses. Common pitfalls include:

- Contamination at the scene or in the laboratory due to poor PPE, re-use of consumables, or crowded workspaces.
- Improper packaging (e.g., storing wet biological stains in sealed plastic which causes degradation and microbial growth).
- Delays in submission to laboratories which lead to decomposition of biological material.
- Incomplete or missing chain-of-custody records.

Courts have acquitted or reduced the weight of evidence where handling lapses created reasonable doubt. For example, recent high-court decisions and media reports show acquittals where procedural gaps in DNA handling were central to the outcome, highlighting how practical errors can trump scientific potential. (Times of India; LiveLaw; Tribune)

The Devakar/Supreme Court matter itself arose from a case where the Apex Court found 'grave procedural lapses' in DNA handling; the Court used the conviction appeal to prescribe nationwide safeguards precisely because improper handling had produced unreliable results in the original trial.

9. Digital forensics and technological developments

Digital devices increasingly hold the key to motive, opportunity and contemporaneous records of criminal activity. Digital forensics requires techniques and legal caution:

- Preservation: imaging the storage media using write-blockers preserves original data for verification; logging of hash values provides an integrity check.
- Isolation: preventing network access (Faraday bags, isolating Wi-Fi) prevents remote

wiping or tampering.

- Cloud and third-party data: lawful processes (judicial orders, mutual legal assistance) are needed to access cloud-stored evidence; preservation notices and legal authorisations can prevent loss of volatile data.

- Tool validation and reproducibility: digital forensic tools should be validated; analysts should maintain repeatable workflows and preserve logs to explain extraction and analysis steps.

INTERPOL (INTERPOL, 2021)'s 'Guidelines for Digital Forensics First Responders' provide an operational framework for seizing digital evidence while protecting its forensic value; these guidelines are widely used by law enforcement to ensure defensible handling of electronics.

10. Recommendations

To strengthen the integrity and utility of forensic evidence in India, the following multi-pronged reforms are recommended:

- Nationwide standard operating procedures (SOPs) for collection, preservation and chain-of-custody that are mandatory for all police units; integrate UNODC (UNODC, Crime Scene Handbook)/INTERPOL (INTERPOL, 2021) templates with local legal requirements.

- Accreditation drive: require ISO/IEC 17025 (ISO/IEC 17025) (or NABL equivalent) accreditation for forensic laboratories handling criminal matters, and provide central funding and technical assistance for upgrades. Accreditation demonstrates technical competence and improves judicial confidence.

- Training and capacity building: scale up the National Forensic Sciences University (NFSU) campuses and invest in continuous professional development for police, medical officers and laboratory analysts. Dedicated training reduces human-error related lapses.

- Digital evidence protocols: adopt validated toolkits, invest in e-forensics platforms and national preservation mechanisms to handle cloud data and encrypted devices.

- Judicial awareness and procedural checklists: courts should routinely request chain-of-custody registers and laboratory accreditation certificates where DNA or other sensitive forensic tests are relied on; judicial checklists will reduce convictions based on poorly handled evidence.

- Transparency and access to raw data: prosecutors and defence counsel should have access to raw laboratory outputs, calibrated instrument logs and analyst notes to enable meaningful confrontation and verification.

Conclusion

Forensic science remains indispensable to modern criminal justice, but its contribution depends on procedural discipline, laboratory competence and clear legal standards. The lifecycle from crime scene to courtroom must be managed as a single chain: loss or error at an early stage cannot be undone by later analysis. Recent judicial interventions, notably the Supreme Court's guidelines on DNA evidence, indicate an era of increasing standardisation and judicial insistence on quality. Implementing the recommendations in this paper will reduce the risk of wrongful conviction, improve conviction integrity, and foster public confidence in forensic science as a reliable adjunct to the rule of law.

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