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The Pivotal Role of Scientific Evidence in Establishing Guilt Beyond Reasonable Doubt: A Doctrinal Analysis of Landmark Judgments

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ABSTRACT

In India's adversarial criminal justice system, the standard of proof **"beyond reasonable doubt"** serves as the ultimate safeguard for individual liberty, demanding that the prosecution eliminate every plausible hypothesis of innocence to reach a state of moral certainty. Historically, trials relied heavily on ocular testimony—evidence that is often shadowed by human fallibility, memory decay, or hostility. Today, scientific evidence—encompassing DNA profiling, ballistics, medical forensics, and digital records—has emerged as the objective "silent witness." This empirical anchor shifts the focus of the judiciary from subjective narratives to verifiable biological and technological data. This doctrinal study analyzes the evolution of forensic jurisprudence through a trajectory of landmark judicial pronouncements. It begins with the foundational principles in Sharad Birdhichand Sarda v. State of Maharashtra and extends to the transformative standards set in Kattavellai @ Devakar v. State of Tamil Nadu. The research further incorporates contemporary insights from rulings such as Prakash Nishad @ Kewat Zinak Nishad v. State of Maharashtra, R. Rajendran v. Kamar Nisha, Manoj v. State of Madhya Pradesh, and Karandeep Sharma @ Razia @ Raju v. State of Gujarat. Central to this analysis is the transition from the Indian Evidence Act to the Bharatiya Sakshya Adhiniyam, 2023 (BSA), which modernizes the admissibility of electronic and forensic records. However, the study juxtaposes these legal advancements against empirical data from the National Crime Records Bureau (NCRB) 'Crime

in India 2023' and Ministry of Home Affairs (MHA) audits. These reports expose persistent systemic gaps—specifically chain-of-custody breaches and procedural lapses at the investigation stage—that frequently lead to the acquittal of the guilty. Through a synthesis of judicial doctrine and empirical findings, this paper demonstrates that while scientific evidence is a powerful tool for establishing guilt, its role remains conditional upon **procedural integrity**. The study concludes by proposing targeted reforms, including **AI-assisted validation protocols** and the mandatory implementation of the "Kattavellai Guidelines" for DNA handling, to ensure that forensic practices remain consistent with the mandate of constitutional due process under Article 21 of the Constitution of India.

1. Introduction

The principle of guilt "beyond reasonable doubt" (BRD) serves as both the moral and constitutional bedrock of India's criminal justice system. Deeply rooted in Article 21 of the Constitution, which guarantees the right to life and personal liberty, this standard mandates that the prosecution prove culpability to a degree that excludes any plausible explanation of innocence. It does not demand absolute mathematical certainty but requires "moral certainty"—a state where the judicial mind is satisfied that no other reasonable conclusion exists. This burden is now codified under the Bharatiya Sakshya Adhiniyam, 2023 (BSA), specifically through provisions governing relevancy (Section 5) and expert opinion (Section 39).

Historically, Indian courts operated within an environment dominated by ocular testimony. However, the inherent vulnerabilities of human memory and the risk of witness hostility often led to significant miscarriages of justice. The steady integration of forensic science—ranging from ballistics in the late 20th century to the revolutionary precision of DNA profiling and digital forensics—has fundamentally transformed the adjudicatory process. With DNA match probabilities often exceeding **1 in 10^{18}**, science offers a level of exclusion that traditional testimony simply cannot match.

Despite this technological leap, the integration of science into the courtroom remains uneven. The National Crime Records Bureau (NCRB) 'Crime in India 2023' report highlights a rising tide of 6.24 million cognizable crimes, yet systemic acquittals continue to occur due to procedural lapses such as

sample contamination and chain-of-custody failures. To combat these vulnerabilities, the Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS) has introduced mandatory safeguards, including the videography of seizures under Section 176(3).

This paper provides a thematic and doctrinal analysis of landmark judgments, focusing on the judiciary's evolving approach to the admissibility and reliability of scientific data. By examining recent precedents—most notably the procedural mandates established in ***Kattavellai @ Devakar v. State of Tamil Nadu***—this study evaluates how the courts are navigating the intersection of technology and law.

Ultimately, this analysis demonstrates that scientifically validated and procedurally pristine evidence is the most reliable instrument for operationalizing the "beyond reasonable doubt" standard. By bridging the gap between forensic potential and investigative reality, the Indian legal system can transform BRD from a constitutional ideal into a verifiable judicial assurance, ensuring that justice is both accurate and consistent with the spirit of Article 21.

2. Literature Review

Scholarly works on the subject highlight both the immense potential and the inherent fragility of scientific evidence in criminal trials. Classic treatises such as Batuk Lal's *Law of Evidence* (2020) and Vepa P. Sarathi's work (2018) classify forensic evidence as "expert opinion" under Section 39 of the Bharatiya Sakshya Adhiniyam, 2023. They emphasise that while such evidence carries significant weight, it must always undergo careful judicial scrutiny and needs to be supported by other corroborative material, as observed by the Supreme Court in *State of HP v. Jai Lal*.

Empirical studies further bring out this dual character. Project 39A's *Death Penalty India Report* (2024) shows that stronger use of forensic science has contributed to a roughly 40% increase in capital convictions since 2010. However, the same report notes an 18% reversal rate in appeals, largely due to procedural mistakes during investigation and evidence handling. International comparisons also offer valuable insights. The UNODC's *Global Study on Homicide* (2023) points out that forensic evidence is used in only about 30% of homicide cases in India, compared to around 85% in the United States, mainly because of inadequate infrastructure and resources.

Recent Indian scholarship has focused more sharply on these issues. Talukdar's article "Conclusiveness of DNA Reports in Indian Rape Cases" (Indian Journal of Medical Ethics, October 2025) and Singh's *Forensic Evidence in Criminal Trials* (2025) critically examine the 8.25% acquittal rate in sexual offence cases. While they appreciate the procedural guidelines laid down in the *Kattavellai* judgment, they also

highlight persistent urban-rural disparities in the quality of forensic work. Similarly, Kumar & Devi (2025) draw attention to the massive backlog of 1.2 million pending samples in Forensic Science Laboratories (FSLs) and the acute shortage of trained experts. Most existing literature, however, examines either the legal or the empirical dimensions in isolation. This paper attempts to bridge that gap by combining judicial doctrines with NCRB data on procedural failures. It also incorporates recent developments, particularly the growing role of AI tools and important judgments delivered in 2025.

3. Methodology:

This study adopts a doctrinal research approach. It involves a qualitative analysis of important judgments delivered by the Supreme Court and various High Courts of India. The primary sources include landmark Supreme Court cases such as *Sharad Birdhichand Sarda v. State of Maharashtra*, *Mukesh v. State (NCT of Delhi)* (Nirbhaya case), *Kattavellai @ Devakar v. State of Tamil Nadu*, *Prakash Nishad @ Kewat Zinak Nishad v. State of Maharashtra*, *R. Rajendran v. Kamar Nisha*, *Manoj v. State of Madhya Pradesh*, and several other recent decisions from 2025. High Court judgments from Delhi, Kerala, Bombay, Madhya Pradesh, Punjab & Haryana, Karnataka, Calcutta, Assam, Gujarat, Rajasthan, and Uttarakhand have also been examined. Only those cases were selected which directly deal with scientific evidence — including DNA profiling, ballistics, medical/forensic reports, digital evidence, and toxicology — and discuss their role in proving guilt beyond reasonable doubt. These judgments were analysed thematically by applying the five "golden rules" laid down in the *Sharad Birdhichand Sarda* case. Secondary sources, including the NCRB's *Crime in India 2023* report, the Ministry of Home Affairs (MHA) 2024 audit of Forensic Science Laboratories, and recent academic papers such as Kumar & Devi (2025), were used to understand the practical impact of these judicial principles on the ground. This combination of doctrinal analysis of case law and empirical data allows for a comprehensive understanding of how scientific evidence is being used — and sometimes misused — in Indian courts, while highlighting the critical importance of maintaining procedural integrity.

4. Conceptual Framework: Scientific Evidence and the Beyond Reasonable Doubt Standard:

The doctrine of proof "beyond reasonable doubt" (BRD) constitutes the moral and constitutional bedrock of India's adversarial criminal justice system. Far from being a mere procedural formality, BRD embodies the fundamental presumption of innocence and safeguards the right to life and personal liberty guaranteed under Article 21 of the Constitution. As authoritatively articulated by the Supreme Court in Gurbachan Singh v. State of Bombay, the prosecution is required to establish the guilt of the accused with such persuasive force that the judicial mind is left with no reasonable or plausible hypothesis

consistent with innocence. This standard demands moral certainty — a high degree of conviction that the accused committed the offence — rather than absolute or mathematical proof, which human affairs rarely permit. It is deliberately more stringent than the civil standard of "preponderance of probabilities" because the consequences of a criminal conviction are grave: deprivation of liberty, social stigma, economic ruin, and, in capital cases, the irreversible loss of life. The importance of BRD in criminal cases is both protective and foundational. It operates as the ultimate bulwark against wrongful convictions, ensuring that the immense power of the State is not exercised lightly. In every criminal prosecution — whether involving murder, rape, terrorism, or economic offences — BRD compels the court to scrutinise the entire body of evidence holistically. It is especially critical in the following situations: (i) cases built entirely or substantially on circumstantial evidence, where no direct eyewitness testimony exists; (ii) offences where testimonial evidence is inherently vulnerable to memory fade, hostility, or fabrication (as frequently seen in sexual offence prosecutions); and (iii) trials where scientific or expert evidence is deployed to bridge evidentiary gaps. In these scenarios, BRD prevents conviction based on suspicion, conjecture, or incomplete chains of inference. Only when the prosecution eliminates every reasonable alternative explanation of innocence does the court reach the threshold of moral certainty required for conviction. Failure to meet this threshold mandates acquittal, irrespective of the strength of individual pieces of evidence taken in isolation. The landmark judgment in Sharad Birdhichand Sarda v. State of Maharashtra crystallised the application of BRD to circumstantial cases through its celebrated five "golden rules." These rules require that: (1) the circumstances from which the conclusion of guilt is drawn must be fully proved; (2) the proved facts must be consistent only with the hypothesis of the accused's guilt; (3) the circumstances must not be explainable on any other reasonable hypothesis; (4) the chain of circumstances must be complete and unbroken; and (5) the cumulative effect must be such that it excludes every hypothesis except the one of guilt. These principles have become the touchstone for evaluating all forms of evidence, including scientific evidence, ensuring that convictions rest on unassailable logic rather than probabilistic speculation.Within this framework, scientific evidence — DNA profiling, ballistics, medical forensics, toxicology, and digital records — assumes a pivotal role as the objective "silent witness." Under the BSA 2023 such evidence is admissible as "expert opinion" under Section 39 (formerly Section 45 of the Indian Evidence Act) only when it is relevant under Section 5. It is never conclusive by itself; rather, it serves as a powerful tool to quantify and objectify the Sarda golden rules. For instance, a DNA random match probability (RMP) of 1 in 10^{18} or higher provides near-mathematical exclusivity, directly satisfying the requirements of completeness and exclusion of alternative hypotheses. Ballistic microscopic matching or verified digital hash values similarly eliminate

plausible sources of doubt. In this manner, scientific evidence elevates BRD from subjective moral certainty to empirically verifiable certainty, thereby strengthening the prosecution's case in complex circumstantial or sexual-offence trials while simultaneously reducing the risk of miscarriages of justice. Yet, as consistently reiterated in Premjibhai Khasiya v. State of Gujarat and reinforced in recent precedents such as Kattavellai @ Devakar v. State of Tamil Nadu, scientific evidence can fulfil the BRD standard only when accompanied by impeccable procedural integrity. The chain-of-custody must be flawless; samples must be collected, preserved, and transported with due diligence (including refrigeration within stipulated timelines and use of tamper-evident seals); and expert reports must comply with BNSS documentation mandates, including videography of seizures. Any breach — unsealed exhibits, delayed analysis, contamination, or absence of cross-examination opportunity — itself introduces reasonable doubt, rendering even the most sophisticated forensic findings inconclusive. Courts treat forensic reports as highly persuasive but advisory, always subject to judicial scrutiny for reliability and constitutional compliance under Articles 20(3) (protection against self-incrimination) and 21 (due process). This conceptual interplay between BRD and scientific evidence underscores a consistent judicial philosophy: while forensics represent the most reliable means of achieving the exacting BRD threshold in the modern era, their probative value is contingent upon procedural purity. Recent rulings analysed in this paper — involving degraded samples, broken custody chains, or delayed expert testimony — repeatedly demonstrate that procedural lapses can transform powerful science into a source of reasonable doubt, compelling acquittal. Thus, BRD not only protects the innocent but also compels investigative agencies to maintain the highest standards of diligence, ensuring that scientific advancements serve justice rather than undermine it. The judgments examined below illustrate this conditional pivotality with remarkable doctrinal consistency.

5. Historical Evolution of Scientific Evidence in Indian Jurisprudence

The incorporation of scientific evidence into Indian criminal jurisprudence represents a gradual yet transformative shift from subjective human testimony to objective empirical validation, always tethered to the BRD standard. This evolution unfolded in distinct phases, each building upon constitutional safeguards and legislative reforms while addressing the inherent limitations of earlier evidentiary practices. Colonial-era foundations under the Police Act, 1861, introduced basic chemical examinations, but post-independence courts initially approached physical evidence cautiously. In Pritam Singh v. State of Punjab, the Supreme Court accepted footprint analysis as corroborative evidence in a circumstantial murder case, marking an early recognition that physical traces could strengthen the "chain of circumstances" without violating Article 20(3). This laid the groundwork for treating forensics not as

standalone proof but as a vital link in excluding alternative hypotheses of innocence. The 1970s and 1980s witnessed formal acceptance of ballistics, reflecting growing judicial confidence in scientific precision. State of UP v. Smt. Sukhbasi upheld a conviction based on microscopic matching of rifling marks on bullets to the accused's firearm. Here, ballistic evidence directly fulfilled the Sarda golden rules by conclusively linking the weapon to the crime, ruling out any plausible alternative source and elevating moral certainty beyond reasonable doubt. The 1990s ushered in the DNA revolution, fundamentally altering the landscape. The Priyadarshini Mattoo case (Delhi High Court 2006, affirmed by Supreme Court in Santosh Kumar Singh v. State through CBI, 2010) exemplified this shift: semen DNA evidence overturned a flawed acquittal, demonstrating how high-probability genetic matches could transcend testimonial weaknesses and satisfy the exclusivity and completeness criteria of Sarda. Constitutional limits soon tempered technological enthusiasm. Selvi v. State of Karnataka banned involuntary narco-analysis, polygraphy, and brain mapping as violations of Article 20(3) (self-incrimination) and Article 21 (privacy), restricting such methods to consensual, corroborative use only. This ruling reinforced that scientific tools must respect due process, preventing any erosion of BRD through coercive "proof." The digital age further refined evidentiary standards. Anvar P.V. v. P.K. Basheer mandated Section 65B certificates (now BSA Section 63) for electronic records like CCTV footage, ensuring tamper-proof integrity. Arjun Panditrao Khotkar v. Kailash Kushanrao extended this to hash-value verification, closing gaps in digital chain-of-custody. The 2023 reforms (BSA/BNSS) codified these advances, elevating electronic and forensic records as primary evidence while mandating procedural safeguards.This historical trajectory reveals a consistent judicial philosophy: science enhances BRD by objectifying the circumstantial chain, but only when collection, preservation, and presentation adhere to constitutional and statutory rigor. The judgments, discussed next, mark the culmination of this evolution by addressing persistent procedural fragility.

6. Landmark Supreme Court Judgments

The Supreme Court has progressively refined the role of evidence, ensuring that scientific findings don't just support a case but often serve as the deciding factor in meeting the **Beyond Reasonable Doubt (BRD)** threshold—particularly in cases built on circumstantial evidence. The following sections examine key rulings thematically, illustrating a steady doctrinal evolution from foundational legal principles to modern procedural mandates.

6.1 Foundational Integration

Sharad Birdhichand Sarda v. State of Maharashtra remains the cornerstone. Toxicology reports confirming arsenic poisoning completed the circumstantial chain, excluding suicide and compelling conviction under the five golden rules. The Court emphasized that scientific findings must be "wholly inconsistent with the innocence of the accused," a principle that continues to guide forensic integration today. This framework has been repeatedly invoked in later cases, including those involving medical evidence in poisoning or injury matters.

6.2 DNA Profiling: Reliability and Safeguards

DNA evidence has emerged as the pinnacle of scientific certainty, yet the Court has consistently demanded impeccable procedural safeguards. In Mukesh v. State (NCT of Delhi) (Nirbhaya case), semen DNA with an intact chain-of-custody provided "unassailable" linkage, upholding death sentences. The judgment underscored that high RMP statistics, when procedurally flawless, eliminate alternative hypotheses, directly satisfying Sarda's exclusivity and completeness tests. Anil @ Anthony Arikswamy Joseph v. State of Maharashtra refined admissibility of STR and Y-STR testing, stressing refrigeration and documentation to prevent degradation. These safeguards ensure DNA remains a reliable "cellular fingerprint."

Kattavellai @ Devakar v. State of Tamil Nadu marked a watershed moment. Despite initial strong DNA matches in a rape-cum-double-murder case, 72-hour delays and absent tamper-evident seals led to acquittal of a death-row convict. The three-judge Bench issued the procedural guidelines on DNA evidence handling (hereinafter "Kattavellai Guidelines") (effective July 15, 2025): (1) use of standardised sterile collection kits; (2) refrigeration of biological samples within 48 hours; (3) mandatory tamper-evident seals; (4) CCTV monitoring of laboratory processing; and (5) maintenance of a centralised digital chain-of-custody register from seizure to court deposition. These Kattavellai Guidelines have reportedly reduced tainted forensic reports and now constitute the nationwide benchmark for forensic practice. The ruling reinforces that procedural fragility can create reasonable doubt, rendering even powerful science inconclusive. Similar lapses resulted in acquittals in Putai v. State of Uttar Pradesh (unsealed exhibits risking contamination), Dashwanth v. State of Tamil Nadu (four-month delay rendering samples degraded from burned remains), and Nilesh Baburao Gitte v. State of Maharashtra (inconclusive postmortem and absent DNA on stains). Prakash Nishad @ Kewat Zinak Nishad v. State of Maharashtra further crystallized the doctrine by holding that an unproven chain of custody for DNA samples renders the evidence unreliable, even when statistical probabilities are high; the Court acquitted the accused

because the prosecution could not demonstrate continuous, tamper-proof handling from seizure to analysis, thereby failing Sarda's completeness test and introducing reasonable doubt. R. Rajendran v. Kamar Nisha reinforced limits on DNA testing in exceptional circumstances, clarifying that courts cannot order DNA profiling as a matter of routine without strong prima facie evidence of non-access or relevance, balancing Article 21 privacy rights with the need for conclusive scientific linkage in criminal prosecutions. Additional rulings like Amlesh Kumar v. State of Bihar and Mohamed Sameer Khan v. State further illustrate the Court's insistence on flawless handling in narcotics and rape-murder contexts, where chemical analysis or biological traces proved decisive only when chains remained intact. Manoj v. State of Madhya Pradesh emphasized the necessity of disclosing random match probability (RMP) in DNA reports; absence of RMP data creates uncertainty, preventing the evidence from satisfying the exclusivity requirement under Sarda.

6.3 Ballistics, Medical, and Digital Forensics

The Supreme Court applies a high degree of rigor to ballistics and medical evidence, ensuring that technical findings are not just present, but conclusive. In Chetan v. State of Karnataka, the ballistic matching of pellets and wads to a seized firearm successfully bridged the "last-seen" gap in a circumstantial murder case. By excluding the possibility of alternative weapons and satisfying the completeness rule, the forensic evidence served as the deciding factor in upholding the conviction. A similar reliance on scientific residues was seen in Jayantibhai Chaturbhai Patel v. State of Gujarat, where ballistic traces were central to proving culpability in explosives cases. Conversely, the Court has demonstrated that inconclusive science cannot sustain a conviction. In Gambhir Singh v. State of UP, the failure of medical reports to establish a definitive cause of death highlighted the critical need for precision and expert cross-examination. Similarly, in Karandeep Sharma @ Razia @ Raju v. State of Gujarat, the Court ordered an acquittal due to a broken chain of custody and the absence of expert testimony, proving that even valid medical evidence loses its legal value if the procedure is flawed. Digital forensics has undergone a similar evolution, most notably through Arjun Panditrao Khotkar, which mandated hash-value verification to prevent the tampering of electronic records. This was further reinforced in State of Maharashtra v. Farooq Mohammed Kasim, emphasizing that metadata in cyber cases must be handled with procedural integrity. Collectively, these rulings demonstrate a seamless doctrinal flow: science must be both technically accurate and procedurally pristine to meet the Beyond Reasonable Doubt (BRD) standard. Furthermore, cases like Govind v. State of Haryana and Badri Mandal v. State of Haryana underscore that flaws in the recovery of evidence, such as unsecured ballistic samples, effectively nullify their scientific value. The limits of forensic evidence are perhaps most clearly

defined in Jay Prakash Yadav v. State of Jharkhand. In this case, a constable was charged with the murder of his superior officer using an INSAS rifle. Although the ballistic expert confirmed that the bullets recovered from the body were fired from the seized rifle, and duty registers linked the weapon to the appellant, the Court acquitted the accused. The Court identified critical gaps in the narrative, including doubts regarding the rifle-exchange testimony and the non-production of the duty register for the date of the offense. Invoking the "Five Golden Rules" from Sharad Birdhichand Sarda v. State of Maharashtra, the Court held that every link in a circumstantial chain must be established so conclusively as to point unerringly to the guilt of the accused and no one else. Even with a direct ballistic link, the prosecution's failure to exclude every other reasonable hypothesis led to an acquittal. This ruling reinforces a fundamental judicial principle: while scientific evidence is highly persuasive, it remains conditional upon an unbroken and complete chain of circumstances to satisfy the BRD threshold.

6.4 Critical Evaluation: The Pivotal Yet Conditional Role of Scientific Evidence

A critical doctrinal reading of the above judgments reveals that scientific evidence performs a pivotal function in establishing guilt beyond reasonable doubt precisely because it objectifies the Sarda golden rules. In Mukesh (Nirbhaya) and Chetan, high-probability DNA and ballistic matches supplied the mathematical exclusivity and unbroken chain that testimonial evidence alone could not provide. Conversely, Kattavellai, Prakash Nishad, Putai, Dashwanth, and Nilesh Gitte illustrate that procedural lapses convert even statistically overwhelming evidence (RMP > 1 in 10^{18}) into a source of reasonable doubt, compelling acquittal. R. Rajendran and Manoj further underscore judicial caution: DNA is not a routine tool but a last-resort corroborative device that must respect Article 21 privacy and Article 20(3) safeguards. This conditional pivotality—powerful when pristine, fatal when tainted—explains the 22% acquittal rate attributable to chain-of-custody breaches (NCRB/MHA data). The Supreme Court's consistent philosophy thus reaffirms that scientific evidence is indispensable for modern BRD adjudication, yet its probative value remains wholly contingent upon flawless investigative and laboratory protocols.

7. Insights from High Court Judgments

High Courts serve as vital laboratories for applying Supreme Court doctrines to regional investigative realities. These rulings often expose implementation gaps while simultaneously reinforcing uniform standards across the country. By analyzing various High Court decisions, we gain granular insights into how admissibility, corroboration, and procedural fidelity are treated in practice.

Delhi High Court: Emphasis on Corroboration

The Delhi High Court has adopted a balanced yet rigorous approach to scientific evidence. In one instance, the Court upheld DNA evidence in a rape appeal despite minor documentation gaps, ruling that independent corroborative testimony could cure technical defects as long as there was substantial compliance with established guidelines. Similarly, in a poisoning homicide where eyewitnesses turned hostile, postmortem toxicology reports provided the necessary links to complete the circumstantial chain, satisfying the "Sarda Rules" and establishing guilt beyond a reasonable doubt. Conversely, the Court has not hesitated to order acquittals when forensic integrity is compromised. In a notable case, the degradation of samples due to cold-chain failure led to an acquittal, prompting the Court to direct strict adherence to the Bharatiya Nagarik Suraksha Sanhita (BNSS) videography mandates. These rulings reflect a preference for objective scientific corroboration in complex urban cases while maintaining the highest standards for evidence collection.

Kerala High Court: Enforcing BNSS Mandates

The Kerala High Court has been particularly stringent regarding procedural enforcement under the new BNSS framework. In Suresh v. State of Kerala, the Court acquitted the accused following the absence of videography during the seizure of DNA samples, treating it as a fatal breach in the chain of custody. In Iyappan v. The Inspector of Police, a ballistic conviction was upheld only after the Court verified digital logs, reinforcing the role of video documentation in excluding the possibility of tampering. Furthermore, in cases like State of Kerala v. Parimal Sahu, acquittals were granted in narcotics matters due to unsealed samples or delayed intervention, emphasizing the necessity of timely preservation.

Bombay High Court: The Contamination Trap

The Bombay High Court’s jurisprudence focuses heavily on the risks of contamination. In the Prasad Rajput case, the Court nullified high-probability DNA matches because the samples were unsealed, ruling that procedural flaws override even the strongest statistical evidence. While the Court upheld a cyber-fraud conviction in State of Maharashtra v. Farooq Mohammed Kasim via certified metadata, it issued a stern warning against unverified digital chains. Additionally, in Yusuf Khan s/o Bahadur Khan v. State of Maharashtra, the Court acquitted the accused due to ballistic mismatches resulting from poor recovery protocols at the crime scene.

Madhya Pradesh, Punjab & Haryana High Courts: Medical and Identification Focus

These courts frequently address the intersection of identification and medical forensics. In Gamar Singh @ Gamariya v. State of Madhya Pradesh, the Court acquitted the accused due to inconclusive DNA from degraded remains, reiterating the mandatory need for proper refrigeration. Deepak Tomar v. State of MP highlighted the importance of age-determination via ossification tests but saw the decision overturned due to procedural lapses. In the Punjab and Haryana High Court, rulings such as Badri Mandal v. State of Haryana and Dharmender v. State of Haryana stressed the absolute necessity of secured firearm recoveries and fingerprint integrity. These cases, along with State of Haryana v. Ashok Kumar, reinforce that biological and ballistic traces are only reliable when the collection process is beyond reproach.

Regional Patterns: Assam, Gujarat, Rajasthan, and Uttarakhand

A review of rulings from other High Courts, such as Abdul Hamid v. State of Assam and **Nazim** & Ors. v. The State of Uttarakhand, reveals a consistent nationwide pattern: DNA and medical evidence succeed when the chain of custody is intact but fail in the face of delays or unsealed exhibits. Similarly, R.K. v. State of Madhya Pradesh and Bhagwat Kushwaha v. State of U.P**.** serve as reminders of the frequent lapses in age-determination protocols in POCSO matters. Across all regions, High Courts uniformly demand procedural fidelity. They adapt Supreme Court precedents to local contexts, highlighting that while forensics can significantly enhance the conviction rate, they must be properly integrated and protected from the moment of recovery to the final courtroom testimony.

8. Challenges, Data Analysis, and Empirical Insights

The empirical data examined in this study reinforces the pivotal role of scientific evidence in establishing guilt beyond reasonable doubt, while simultaneously highlighting the serious procedural vulnerabilities that frequently undermine its effectiveness. Although the judiciary has consistently advocated for excellence in forensic practices, institutional realities continue to pose significant challenges. The Ministry of Home Affairs (MHA) 2024 audit of Forensic Science Laboratories reveals a massive backlog of 1.2 million pending samples and a shortage of nearly 5,000 trained experts. NCRB data for 2023–2025 shows that forensic evidence is being utilised in approximately 75% of murder investigations. However, procedural lapses, particularly breaches in the chain of custody, contribute to around 22% of acquittals. The situation is even more concerning in sexual offence cases, where mishandling of forensic evidence leads to an acquittal rate of 8.25%. Several critical challenges emerge from the data. Chain-of-custody breaches remain the most prominent issue, resulting in higher acquittal rates in states like Bihar, where

Forensic Science Laboratory vacancies stand at nearly 78%. Expert shortages have led to 18% of forensic reports being rejected, with states such as Telangana (66%) and Odisha (60%) being the worst affected. Sample degradation accounts for about 12% of inconclusive reports, largely due to delays in refrigeration and poor transportation facilities, especially in remote areas. Digital evidence handling suffers from 15% error rates in cyber cases, while emerging gaps in digital and AI readiness are causing 10–15% errors in metadata and forensic analysis. Judicial responses to these issues have been consistent and instructive. In *Kattavellai @ Devakar v. State of Tamil Nadu*, the Supreme Court laid down mandatory guidelines for DNA evidence handling, including the maintenance of a digital chain-of-custody register. The Court has also emphasised the need for timely refrigeration of biological samples within 48 hours. In cases involving digital evidence, judgments such as *Anvar P.V. v. P.K. Basheer*, *Arjun Panditrao Khotkar*, and *Farooq Mohammed Kasim* have strengthened certification and hash-value verification requirements. High Courts, including the Chhattisgarh High Court, have repeatedly urged better training for investigators and experts, while stressing the importance of effective cross-examination of forensic witnesses. When forensic evidence is collected and preserved properly, it significantly strengthens the prosecution's case. NCRB 2023 data indicates a 68% rise in convictions in sexual offence cases supported by robust forensic evidence, with Andhra Pradesh achieving an impressive 96% resolution rate in serious crimes. However, procedural flaws often transform this powerful tool into a source of reasonable doubt. Marked regional disparities further compound the problem. States like Karnataka and Kerala show relatively better preparedness, whereas Bihar, Uttar Pradesh, and Haryana continue to struggle with over 70% vacancy rates in forensic laboratories. These inequities are particularly evident in remote areas and complex cases involving disfigured bodies, as observed in *Arun Kumar M. v. State*. These empirical patterns directly correspond with the five golden rules laid down in *Sharad Birdhichand Sarda v. State of Maharashtra*. A broken chain of custody or delayed analysis inevitably fails the test of completeness, leading to acquittals in several cases such as *Govind v. State of Haryana* and *Mohamed Sameer Khan v. State*. The persistent issues of underfunding, inadequate infrastructure, and lack of trained personnel pose a serious threat to the Ministry of Home Affairs' target of achieving 80% forensic utilisation by 2030. Without urgent and comprehensive reforms, the transformative potential of scientific evidence in delivering objective justice will remain largely unrealised — especially in POCSO cases and trials relying heavily on circumstantial and medical evidence, where forensic science plays a crucial yet highly fragile role.

9. Recommendations

Based on a comprehensive analysis of current systemic challenges—including empirical data on forensic backlogs, state-level personnel vacancies, and recurring procedural lapses in sensitive areas like age-determination and circumstantial evidence—the following multi-pronged reforms are proposed to modernize the criminal justice framework:

1. Legislative Reforms

- **Codifying Forensic Standards:** Amend the Bharatiya Sakshya Adhiniyam (BSA) to codify specific scientific thresholds, such as a Random Match Probability (RMP) of $>10^{15}$ for a rebuttable presumption of linkage in DNA cases.
- **Mandatory Judicial Checklists:** Implement a statutory "Forensic Checklist" based on the *Sarda* principles, requiring judges to certify that the scientific chain of custody is complete before admitting forensic evidence.
- **Privacy-Centric DNA Regulation:** Introduce a robust DNA regulation law that balances investigative needs with civil liberties, featuring mandatory "right to be forgotten" clauses for the automatic deletion of profiles following an acquittal.

2. Institutional Strengthening

- **Infrastructure Expansion:** Accelerate the establishment of 50 new **ISO 17025-accredited** Forensic Science Laboratories (FSLs) by 2030, effectively utilizing the proposed $₹30,000$ crore national investment.
- **National Oversight Body:** Establish an independent National Forensic Regulatory Authority to conduct periodic audits, set ethical standards, and ensure that all experts hold mandatory certifications from the National Forensic Sciences University (NFSU).
- **Bridging Regional Disparities:** Implement a targeted funding model to address high vacancy rates and infrastructure deficits in specific regions, ensuring that remote areas have access to the same forensic quality as metropolitan centers.

3. Capacity Building and Training

- **Interdisciplinary Workshops:** Launch annual, mandatory forensic workshops for over 12,000 judicial officers and investigators. Focus areas should include AI-driven forensics, complex DNA interpretation, and the statistical weight of evidence.
- **BNSS Compliance:** Provide specialized training on Bharatiya Nagarik Suraksha Sanhita (BNSS) mandates, specifically focusing on the technical requirements for videography during seizures and maintaining digital integrity.

4. Technological Integration & Accountability

- **Blockchain Chain-of-Custody:** Deploy a national, blockchain-based application to track the movement of evidence from the crime scene to the laboratory, making the record immutable and transparent.
- **Enhanced Monitoring:** Upgrade the National Crime Records Bureau (**NCRB)** modules to specifically track forensic turnaround times and their impact on case outcomes.
- **AI for Backlog Management:** Integrate Artificial Intelligence tools to assist in the preliminary sorting of samples and to conduct "bias audits" on emerging forensic tools to ensure they remain neutral and objective.

10. Conclusion:

From the foundational framework established in Sharad Birdhichand Sarda v. State of Maharashtra, which crystallized the "Five Golden Rules" for evaluating circumstantial evidence, to the modern procedural mandates in Kattavellai @ Devakar v. State of Tamil Nadu, scientific evidence has fundamentally transformed the "Beyond Reasonable Doubt" (BRD) standard in Indian criminal jurisprudence. What was once a reliance on subjective moral certainty drawn from oral testimony has evolved into an objective, empirically verifiable form of judicial assurance. Today, DNA profiling, ballistics, toxicology, and digital records serve as the "silent witness," capable of quantifying exclusivity and consistency with the guilt hypothesis while rigorously excluding innocent alternatives. This doctrinal analysis of Supreme Court and High Court judgments reveals a consistent judicial philosophy: while scientific evidence is highly persuasive and often decisive, its probative value is entirely contingent upon impeccable procedural integrity. Rulings like Mukesh v. State (NCT of Delhi) (the Nirbhaya case) illustrate how a flawless chain-of-custody and high random match probabilities provide unassailable

linkage. Conversely, cases such as Putai v. State of Uttar Pradesh and Dashwanth v. State of Tamil Nadu underscore that even the most powerful forensic findings are rendered inconclusive by procedural lapses—such as unsealed exhibits, delayed refrigeration, or broken documentation—compelling the court to acquit. High Courts have acted as vital "laboratories of application," adapting Apex Court doctrines to regional realities and exposing persistent implementation gaps across the country. Their jurisprudence reinforces uniform standards of admissibility and preservation, highlighting the adversarial system's demand for rigorous scrutiny of expert opinions under Section 39 of the Bharatiya Sakshya Adhiniyam (BSA), 2023. The scale of this challenge is reflected in empirical data. With the National Crime Records Bureau (NCRB) 2023 report recording over 6.24 million cognizable crimes, the pressure on forensic infrastructure is immense. Ministry of Home Affairs audits reveal that while forensics are now central to serious investigations, systemic vulnerabilities—such as expert shortages, sample degradation, and massive backlogs—continue to contribute to high acquittal rates. These gaps threaten the promise of science as a cornerstone of justice. However, the evolving legal landscape—particularly the Kattavellai Guidelines—signals a strong judicial commitment to reform. By mandating standardized sterile kits, tamper-evident seals, CCTV monitoring, and digital tracking, the judiciary is pushing for a more resilient system. Moving forward, the integration of blockchain-enabled chain-of-custody systems, targeted capacity building for the judiciary, and legislative refinements to the BSA will be essential to bridging current infrastructure divides. Ultimately, scientific evidence is indispensable for achieving judicial certainty in a modern democracy. When collected and presented with unwavering procedural rigor, it elevates the BRD standard from an abstract constitutional ideal under Article 21 to a practical instrument of verifiable justice. This alignment of forensic practice with constitutional due process ensures that the guilty are convicted with precision while the innocent remain steadfastly protected, thereby reinforcing public confidence in the rule of law.

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