Educational Administration: Theory and Practice
2021, 27(2), 1175-1187
ISSN: 2148-2403
https://kuey.net/ **Research Article**

Science On Trial: A Critical Study of The Role of DNA And Forensic Evidence in Indian Courts

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Citation: Lairenjam Dhanamanjuri Devi, (2021) Science on Trial: A Critical Study of The Role of DNA And Forensic Evidence in Indian Courts, *Educational Administration: Theory and Practice*, 27(2) 1175-1187
Doi: 10.53555/kuey.v27i2.10303

ARTICLE INFO
Submission - 16 June, 2021
Acceptance- 25 June, 2021

ABSTRACT
This paper critically examines the legal, procedural, and constitutional dimensions of DNA and forensic evidence in the Indian criminal justice system. It explores the statutory framework, including the Indian Evidence Act, 1872, and the Criminal Procedure Code, 1973, alongside emerging legislative efforts like the DNA Technology (Use and Application) Regulation Bill, 2019. Judicial attitudes have evolved from cautious admissibility to increasing reliance on DNA, with key rulings such as *Krishna Kumar Malik v. State of Haryana*, 2011, and *Mukesh v. State (NCT of Delhi),* 2017 affirming its probative value. However, procedural lapses, infrastructural inadequacies, and ethical dilemmas persist. The study identifies systemic weaknesses such as lack of standardization, delays in forensic labs, and the risks of treating DNA evidence as infallible. Drawing from Indian and international jurisprudence, the research proposes reforms focused on consent, privacy, expert training, and institutional accountability to align scientific practices with constitutional mandates and ensure fair trials.

Key Words: DNA evidence, forensic science, Indian courts, constitutional rights, criminal justice reform

1. INTRODUCTION

Background of the Study

The use of forensic science in criminal investigations has brought a transformative shift in legal systems across the world. Among the various forensic tools available, Deoxyribonucleic Acid (DNA) analysis has proven to be exceptionally precise in identifying individuals, thus playing a crucial role in both convicting perpetrators and exonerating the innocent (National Research Council, 2009). In India, the application of DNA evidence in criminal cases gained prominence in the 1990s and has since become increasingly important in prosecuting cases of sexual assault, murder, and paternity disputes (Law Commission of India, 2005).

However, this scientific advancement has also brought forth numerous challenges. The absence of a comprehensive regulatory framework, issues in evidence collection, backlog in forensic laboratories, lack of accreditation of forensic labs, and limited awareness among legal professionals have resulted in misapplication or misinterpretation of DNA evidence in several cases (Kaur & Reddy, 2020). For example, in *State of Himachal Pradesh v. Rajiv Jassi,* 2016, the Himachal Pradesh High Court raised serious doubts about the reliability of DNA evidence due to improper handling and lack of standard procedures.

Literature Review

The role of DNA and forensic evidence in the Indian criminal justice system has been critically assessed, which underscores both its potential and its systemic vulnerabilities. Scholars concur that DNA evidence offers significant promise in convicting offenders and exonerating the innocent. Bandyopadhyay (2010) affirms the scientific reliability of DNA profiling but simultaneously cautions against its ethical and procedural shortcomings, particularly in relation to consent, privacy, and long-term data retention. Kumar and Singh (2019) further highlight the constitutional implications of DNA profiling, arguing that in the absence of robust procedural safeguards, such evidence risks violating fundamental rights. Their findings reveal that although courts increasingly admit DNA evidence, its evidentiary value is undermined by the lack of regulatory consistency and comprehensive legislative oversight.

Chowdhury (2017) contextualizes the discussion within the broader framework of constitutional rights, noting that poorly regulated forensic practices—akin to involuntary techniques like narco-analysis—are at odds with

the right to privacy as articulated in *Justice K.S. Puttaswamy v. Union of India,* 2017. Echoing this concern, Raj and Menon (2018) warn against the indiscriminate use of scientific evidence without sufficient judicial scrutiny and advocate for greater awareness among legal professionals regarding its limitations. In a comparative framework, Edmond (2015) critiques the legal system's uncritical reliance on forensic science, pointing out that many methods lack rigorous scientific validation and can lead to miscarriages of justice when not thoroughly tested in adversarial proceedings.

Institutional shortcomings also exacerbate these problems. Sharma and Kumar (2019) examine the systemic deficiencies in Indian forensic laboratories, including inadequate quality control, lack of staff training, and accreditation issues, which collectively compromise the reliability of forensic outputs. These infrastructural gaps, as revealed in Project 39A's reports from 2016 to 2019, are particularly dangerous in capital cases, where courts often rely on unchallenged forensic reports due to limited defense resources. Importantly, concerns over consent, oversight, and data protection were already well-documented. The Centre for Internet and Society (2013), in an early policy analysis of the Draft DNA Bill, warned that the proposed framework lacked critical safeguards and enabled excessive state discretion over genetic data without adequate accountability mechanisms.

This literature converges on the insight that while DNA technology can greatly enhance criminal adjudication, its unregulated or inadequately regulated use introduces substantial risks. To harness its potential effectively, India's legal system must adopt rigorous statutory frameworks, ensure infrastructural capacity, and foster greater scientific literacy among judges, lawyers, and law enforcement officials.

Research Gap

While prior studies have examined the scientific and policy aspects of DNA evidence, there remains a lack of comprehensive legal critique that focuses on the judicial interpretation, statutory lacunae, and institutional inefficiencies related to DNA evidence in India. Moreover, most existing literature is either scientifically technical or narrowly focused on policy, leaving a void in analyzing how courts have grappled with these evidentiary challenges.

Rationale of the Study

The relevance of this study lies in the growing reliance of Indian courts on forensic evidence, especially DNA, in criminal adjudication. While the scientific validity of DNA analysis is well-established, its procedural and legal handling in India remains underdeveloped and inconsistent. The introduction of the DNA Technology (Use and Application) Regulation Bill, 2019, intended to regulate DNA profiling, has sparked significant debate due to concerns over privacy, consent, and oversight mechanisms (PRS Legislative Research, 2019).

Furthermore, various cases such as the *Aarushi–Hemraj double murder case* (*Dr. Nupur Talwar v. CBI*, 2012) and the *Shopian rape and murder case* (The Hindu, 2009) demonstrate the inadequate implementation and oversight of forensic procedures. Therefore, there is a compelling need to evaluate the role and limitations of DNA evidence in the Indian judicial system.

Research Questions

This paper seeks to address the following key research questions:

1. What is the current legal and institutional framework governing the use of DNA evidence in Indian criminal courts?
2. How have Indian courts interpreted and evaluated DNA evidence in criminal trials?
3. What are the primary procedural, ethical, and infrastructural challenges in the use of DNA evidence in India?
4. Does the DNA Technology (Use and Application) Regulation Bill, 2019, sufficiently address concerns about privacy, standardization, and judicial fairness?

Methodology

This study adopts a doctrinal legal research methodology, involving the critical examination of statutory provisions, judicial decisions, Law Commission reports, and the DNA Technology (Use and Application) Regulation Bill, 2019. It relies on qualitative analysis of secondary data, including academic journal articles, government reports, and news archives. Prominent case laws are examined to understand the judicial stance on DNA evidence.

Scope and Limitations

The scope of this study is limited to the use of DNA evidence in the Indian criminal justice system. While references to civil matters such as paternity disputes are made, the focus remains on criminal trials. The study does not evaluate DNA technologies themselves from a scientific standpoint but critiques their legal regulation, procedural implementation, and judicial application. It is further limited by its reliance on publicly available data and case law, excluding empirical data from forensic institutions due to accessibility constraints.

2. LEGAL AND PROCEDURAL FRAMEWORK

The integration of DNA and forensic evidence into the Indian legal system has largely evolved within the frameworks of existing procedural and evidentiary laws. The two principal statutes governing the use of forensic evidence in Indian courts are the Indian Evidence Act, 1872, and the Criminal Procedure Code (CrPC), 1973. These laws, however, were enacted when forensic science was in its infancy and thus require reinterpretation and supplementation in light of modern scientific developments.

2.1 Indian Evidence Act, 1872

Under Section 45 of the Indian Evidence Act, the opinion of experts, including forensic scientists, is admissible when the court has to form an opinion upon a point of science, art, or identity (Indian Evidence Act, 1872). This provision forms the primary statutory basis for admitting DNA reports and other forensic evidence in legal proceedings. In *State of Maharashtra v. Damu,* 2000, the Supreme Court upheld the admissibility of DNA evidence and observed that such scientific methods can provide strong corroborative value, especially in cases involving serious crimes such as rape and murder.

In addition, Section 65B of the Evidence Act provides for the admissibility of electronic records and is frequently invoked in cases involving digital forensics. The Supreme Court in *Anvar P.V. v. P.K. Basheer,* 2014 clarified the requirements for the admissibility of electronic records, holding that only those accompanied by a certificate under Section 65B(4) can be admitted as evidence.

2.2 Criminal Procedure Code, 1973

The CrPC complements the Evidence Act by providing for the procedural aspects of forensic investigation. Section 53 allows a medical practitioner to examine an accused at the request of a police officer when it is likely to afford evidence related to the offence. Section 53A, added after the Criminal Law (Amendment) Act, 2005, provides for the medical examination of persons accused of rape. Section 164A mandates the prompt medical examination of a rape victim, which includes collection of DNA and other biological samples (Criminal Procedure Code, 1973).

These provisions have been crucial in cases involving sexual violence, where biological samples collected from the victim and accused are often decisive in linking or absolving individuals. In *Mukesh & Anr v. State (NCT of Delhi),* 2017, also known as the Nirbhaya case, DNA evidence played a pivotal role in establishing the presence of the accused at the crime scene.

2.3 The DNA Technology (Use and Application) Regulation Bill, 2019

Recognizing the need for a statutory framework to govern the use of DNA in legal contexts, the **DNA Technology (Use and Application) Regulation Bill, 2019** was introduced in Parliament. The Bill was designed to regulate the use of DNA technology for identification in criminal and civil matters. It proposed the establishment of national and regional DNA data banks, the formation of a DNA Regulatory Board, and a system of accreditation for DNA laboratories (PRS Legislative Research, 2019).

However, concerns about the Bill's privacy safeguards emerged early. Legal experts and civil society organizations highlighted potential issues with consent, especially regarding vulnerable populations such as children and survivors of sexual assault (Centre for Internet and Society, 2013). One of the primary criticisms was the lack of adequate oversight mechanisms, which could facilitate unauthorized access to or misuse of sensitive genetic information. Critics also noted the Bill's failure to harmonize with emerging data protection frameworks, particularly in light of evolving jurisprudence on the right to privacy (Centre for Internet and Society, 2013).

2.4 Forensic Reliance under Special Legislations

The increasing reliance on scientific and forensic evidence is not confined to general criminal law but is also reflected in various special statutes. Laws such as the Protection of Children from Sexual Offences (POCSO) Act, 2012 and the Narcotic Drugs and Psychotropic Substances (NDPS) Act, 1985 demonstrate this trend. The POCSO Act mandates prompt medical examination of the victim, including DNA sample collection, to corroborate allegations of sexual abuse (Section 27). Similarly, the NDPS Act places considerable weight on chemical analysis reports from forensic laboratories to establish the nature and quantity of seized substances (Section 36A(4)).

However, despite the central role of forensic science in these legislations, implementation challenges persist. Forensic laboratories in India face chronic issues such as underfunding, lack of trained personnel, delayed reports, and absence of standardized operating procedures. These systemic weaknesses often result in questionable forensic conclusions that can jeopardize fair trial rights and lead to wrongful convictions or acquittals.

The Law Commission of India (2005), in its 185th report, identified these critical gaps and recommended a legal framework to accredit forensic laboratories, set quality control standards, and ensure accountability in forensic reporting. It emphasized that forensic evidence must be both scientifically reliable and procedurally sound to hold evidentiary value. The Commission also noted the absence of a statutory obligation for the

defense to be provided timely and equal access to forensic reports, which could undermine the adversarial nature of the criminal justice process.

2.5 Evolution of Legal Framework Governing DNA and Forensic Evidence in India

India's legal treatment of forensic and DNA evidence has historically relied on broad and somewhat outdated statutory provisions, particularly the Indian Evidence Act, 1872 and the Criminal Procedure Code (CrPC), 1973. Section 45 of the Evidence Act allows expert opinions, including those of forensic experts, to be admitted in court when scientific, technical, or other specialized knowledge is required. DNA evidence, although not specifically mentioned, is typically introduced under this provision (Indian Evidence Act, 1872).

Further procedural support for forensic collection is provided under Sections 53, 53A, and 164A of the CrPC, which permit medical and forensic examinations of accused persons and victims, especially in sexual offence cases. For instance, Section 53A, introduced after the 2005 Criminal Law (Amendment) Act, explicitly allows for the collection of bodily substances, including DNA, from individuals accused of rape.

Judicial pronouncements have gradually affirmed the role of scientific evidence in securing convictions and ensuring justice. In *State of Maharashtra v. Damu* (2000), the Supreme Court upheld the admissibility and corroborative value of DNA evidence. In the *Nirbhaya case* (*Mukesh & Anr v. State (NCT of Delhi)*, 2017), DNA evidence played a pivotal role in linking the accused to the crime scene and strengthening the prosecution's case.

Despite these advances, the absence of a specific DNA law has led to inconsistent standards and practices across states and institutions. Until a comprehensive regulatory framework is enacted, reliance on DNA evidence remains legally valid but operationally vulnerable. Without robust oversight, standardization, and protection of individual rights, forensic science in India risks serving as a double-edged sword, capable of both advancing and obstructing justice.

2.6 Judicial Interpretation and Evolving Standards

Judicial attitudes toward DNA evidence have generally affirmed its scientific reliability but have consistently highlighted the importance of procedural rigor. In *Musheer Khan v. State of Madhya Pradesh*, 2010, the Supreme Court emphasized that forensic reports, including DNA analysis, cannot be relied upon alone; their evidentiary value depends on a complete chain of custody and contextual corroboration.

Further, in *Selvi v. State of Karnataka*, 2010, the Supreme Court reinforced the constitutional dimensions of forensic evidence. It held that involuntary use of scientific techniques, though distinct from DNA, violates Articles 20(3) and 21 by undermining personal autonomy and privacy. This ruling, while not specific to DNA, sets essential legal standards of consent and voluntariness that also apply to DNA collection and usage.

3. ADMISSIBILITY AND RELIABILITY OF DNA EVIDENCE

The application of DNA evidence in Indian courts has highlighted key issues of scientific reliability, procedural compliance, and constitutional rights. Although DNA profiling is widely accepted as a robust forensic tool, its evidentiary value in judicial proceedings depends on how accurately it is collected, handled, preserved, and presented (Bandyopadhyay, 2010; Law Commission of India, 2005; *Musheer Khan v. State of Madhya Pradesh*, 2010).

3.1 Collection and Preservation Protocols

Chain of Custody

The integrity of DNA evidence relies significantly on an unbroken and thoroughly documented chain of custody, tracking the movement and handling of samples from collection to court submission. The absence of such documentation risks contamination or tampering, which can invalidate the evidence. The Supreme Court in *State of Rajasthan v. Kashi Ram,* 2006 held that even scientifically sound evidence can be inadmissible if the handling process is flawed, stressing that procedural adherence is as vital as scientific accuracy.

In India, studies have pointed out systemic issues such as inconsistent evidence tracking, lack of trained forensic personnel, and inadequate infrastructure in many forensic laboratories (Bandyopadhyay, 2010). The Law Commission of India (2005), in its 185th Report, emphasized the importance of standard operating procedures (SOPs) and recommended the creation of a national system for the accreditation and oversight of forensic labs. Similarly, Sharma and Kumar (2019) noted that many Indian labs suffer from poor documentation standards and limited capacity, undermining the evidentiary value of DNA samples. Therefore, courts often assess not only the scientific findings but also the procedural safeguards accompanying DNA evidence.

Legal Issues in Unauthorized or Improper Collection

DNA evidence, although generally classified as physical (non-testimonial) evidence, can still raise constitutional concerns if collected improperly. Article 20(3) of the Indian Constitution protects individuals against self-incrimination, and Article 21 ensures the right to privacy and personal liberty. The Supreme Court's decision in *Selvi v. State of Karnataka,* 2010 declared that involuntary administration of forensic techniques like narco-analysis, polygraph, and brain mapping violates the right against self-incrimination. While DNA

profiling was not directly addressed, the judgment laid down essential standards for voluntariness and consent in the use of scientific evidence.

Additionally, the landmark judgment in *K.S. Puttaswamy v. Union of India*, 2017 affirmed the right to privacy as a fundamental right under Article 21. This decision has significant implications for the collection and use of biometric and genetic information. Without clear legislative guidance, courts are tasked with balancing the utility of DNA evidence against fundamental rights, especially in cases where samples are collected without informed consent or judicial oversight (Gupta, 2020; Kumar & Singh, 2019).

Legal scholars have called for a comprehensive regulatory framework governing the collection, storage, and use of DNA evidence. The pending DNA Technology (Use and Application) Regulation Bill, 2019 seeks to address some of these issues. In the meantime, courts have shown caution in admitting DNA evidence that lacks procedural rigor or infringes on individual rights (Narayan & Raghavan, 2020).

3.2 Judicial Standards for Admissibility

Relevance and Reliability of DNA Evidence

The admissibility of DNA and other forensic evidence in Indian courts is governed by Section 45 of the Indian Evidence Act, 1872, which permits expert opinions if they are both relevant and reliable. Relevance pertains to whether the evidence is connected to a material fact in the case, while reliability concerns the scientific credibility of the techniques used to produce the evidence (Indian Evidence Act, 1872). In *Krishna Kumar Malik v. State of Haryana,* 2011, the Supreme Court affirmed the evidentiary value of DNA profiling, recognizing it as a scientifically reliable method. The Court held that when DNA evidence is obtained and analyzed through proper procedures, it serves as a powerful tool in the administration of justice, particularly in sexual assault cases. It further emphasized that forensic reports should not be disregarded and must be accorded due significance, provided that the chain of custody and procedural safeguards are maintained. This judicial stance underscores the need for rigorous adherence to scientific and procedural standards in forensic analysis to ensure that DNA evidence not only meets the threshold of admissibility but also contributes meaningfully to fact-finding in criminal trials.

Need for Corroboration

Despite its scientific rigor, DNA evidence in Indian courts is rarely treated as conclusive and typically requires corroboration when procedural deficiencies arise. In *Harjinder Kaur v. State of Punjab,* 2012, the Punjab and Haryana High Court acknowledged the value of DNA evidence but stressed that its admissibility depends on proper documentation, strict maintenance of the chain of custody, and the prevention of contamination. Similarly, in *Musheer Khan v. State of Madhya Pradesh,* 2010, the Supreme Court emphasized that while forensic evidence can be crucial, it must be corroborated by other material evidence, especially when procedural lapses are suspected. The Court underscored that DNA results, though scientifically valid, cannot override gaps in investigative or evidentiary processes. Likewise, in *State of Rajasthan v. Kashi Ram,* 2006, the Supreme Court reiterated that forensic evidence alone is insufficient unless it is handled with procedural integrity. Scholars such as Bandyopadhyay (2010) also support this judicial trend, highlighting that poor infrastructure, sample degradation, and human error frequently undermine the reliability of DNA results in Indian courts. These cases and scholarly assessments collectively illustrate that while DNA profiling is a powerful forensic tool, its evidentiary weight depends fundamentally on procedural fairness and legal safeguards.

Key Judicial Precedents on DNA Evidence

Judicial interpretation has played a crucial role in shaping the legal framework for the admissibility and evaluation of DNA and other forensic evidence in India. Courts have repeatedly emphasized the balance between scientific advancement and constitutional safeguards, particularly in criminal proceedings. In *Selvi v. State of Karnataka,* 2010, the Supreme Court held that involuntary administration of scientific techniques violates Article 20(3) of the Constitution, which protects against self-incrimination. The Court's reasoning laid a constitutional foundation for scrutinizing all forms of scientific evidence, including DNA, under the principles of consent, privacy, and due process. In *Krishna Kumar Malik v. State of Haryana,* 2011, the Supreme Court emphasized that modern scientific techniques must be utilized to bring perpetrators to justice. The Court noted that when collected and analyzed properly, DNA evidence can be pivotal in confirming guilt, especially in cases where other evidence is limited or circumstantial. Conversely, in *Dr. Nupur Talwar v. CBI,* 2012, the Supreme Court examined significant procedural lapses in the handling of forensic evidence in the Aarushi-Hemraj double murder case. The Court highlighted concerns about DNA sample contamination, improper sealing, and failure to follow standard operating protocols, which collectively cast doubt on the reliability of the evidence and demonstrated the necessity for rigorous procedural compliance.

In *Mukesh v. State (NCT of Delhi),* 2017, relating to the Nirbhaya gang rape case, the Supreme Court relied heavily on DNA profiling to affirm the conviction, considering it part of a robust evidentiary framework supported by medical and circumstantial proof. Similarly, in *Jagroop Singh v. State of Punjab,* 2012, the Punjab and Haryana High Court stressed the importance of corroborative support for DNA evidence, reflecting judicial caution where procedural doubts exist.

DNA evidence holds strong scientific credibility; however, its acceptance in Indian courts is governed by stringent legal scrutiny. Judicial evaluation focuses on procedural integrity, such as the maintenance of the

chain of custody and proper collection methods, alongside statutory provisions under Section 45 of the Indian Evidence Act and Section 53 of the Criminal Procedure Code. Additionally, its use must align with constitutional protections under Articles 20 and 21. Notably, Indian courts typically treat DNA evidence as corroborative rather than conclusive, reflecting a careful yet evolving judicial stance toward forensic science.

4. FORENSIC LABS IN INDIA: CAPACITY AND CHALLENGES

4.1 State of Infrastructure

Lack of Standardization and Accreditation

India's forensic infrastructure has historically lacked uniform accreditation and regulatory oversight. While the National Accreditation Board for Testing and Calibration Laboratories (NABL) offers accreditation under ISO/IEC 17025 to ensure competence and reliability in laboratory testing, its application to forensic laboratories has been inconsistent across states and the central government.

A notable development occurred in September 2019, when the Delhi Forensic Science Laboratory in Rohini received NABL accreditation, making it one of the few labs in the country to achieve this distinction (Press Trust of India [PTI], 2019; Business Standard, 2019). Similarly, the State Forensic Science Laboratory at Junga, Himachal Pradesh, obtained NABL accreditation during the 2018–2019 period, making it the fifth state lab to be certified under ISO standards (Government of Himachal Pradesh, 2019; Tribune, 2019).

Despite these improvements, NABL does not publicly publish annual figures specifying how many forensic labs are accredited, making it difficult to assess national coverage (NABL, n.d.-a). The absence of a mandate for compulsory accreditation results in a fragmented quality landscape, with several state and private forensic labs operating without standardized procedures or external oversight (Singh, 2018).

Such disparities in lab accreditation and operational standards compromise the consistency and credibility of forensic evidence submitted in court. Courts have, in various cases, expressed concern over the admissibility of forensic reports produced by labs lacking accreditation or quality control measures.

Delays and Backlogs in Forensic Laboratories

Forensic laboratories in India also face severe backlogs and delays, particularly in the analysis of DNA evidence, which is critical in sexual assault and homicide investigations.

Data from the Directorate of Forensic Science Services showed that over 12,072 DNA samples from sexual assault cases were pending in just three of the six Central Forensic Science Laboratories (CFSLs) equipped to handle DNA analysis—namely, those in Chandigarh, Hyderabad, and Kolkata (Das Gupta, 2018). Each of these labs could process only about 500–600 cases annually, indicating an overwhelming volume-to-capacity mismatch.

The problem is not limited to central labs. The Rohini FSL in Delhi, for instance, accumulated a backlog of 7,135 forensic reports between 2006 and 2018, with delays of several months even for routine cases (Singh, 2018). These procedural lags have a cascading effect on the criminal justice system, leading to prolonged investigations and delayed trials.

Compounding the issue is the quality of analysis. A 2018 report by the Thomson Reuters Foundation revealed that less than 50% of the over 25,000 annual DNA testing requests were processed, and approximately 20% of completed reports were rejected in court due to contamination or procedural errors (Thomson Reuters Foundation, 2018). These lapses not only erode the reliability of forensic evidence but also risk wrongful convictions or acquittals due to compromised evidentiary value.

In sum, inadequate lab capacity, lack of standardization, and frequent quality issues together hinder the efficient and just resolution of criminal cases in India.

4.2 Lack of Trained Experts

India's forensic science infrastructure continues to be hampered by a severe shortage of trained experts and scientific personnel, a problem that has persisted across both central and state laboratories. The Comptroller and Auditor General (CAG) of India, in multiple reports between 2015 and 2017, identified widespread vacancies in sanctioned posts across Forensic Science Laboratories (FSLs). For instance, in Uttar Pradesh, four regional FSLs operated with only 40% of the sanctioned staff strength in 2016, leading to a backlog of over 15,000 forensic samples—up from 6,617 in 2011 (Comptroller and Auditor General [CAG], 2016). Similarly, Mumbai's Kalina laboratory reported a 29% vacancy rate in scientific posts as of early 2017, contributing to a case pendency of over 34,000 forensic samples, including DNA (Kakodkar, 2017).

The staffing shortfall is compounded by concerns over the competence and qualification of existing personnel. According to the Forensic Science India Report (2013–2017) by Project 39A and the Ministry of Home Affairs, approximately 40% of the 3,211 sanctioned scientific positions across 26 laboratories remained unfilled, and more than two-thirds of the unfilled posts were for technical and scientific roles (Project 39A, 2018). In some labs, especially at the state level, contractual or underqualified personnel were employed to conduct complex analyses. For example, the Karnataka state audit noted that individuals with degrees in general science disciplines such as zoology were assigned to cyber and chemical forensics roles, fields for which they lacked adequate training (Paliath, 2023). This mismatch not only threatens the scientific integrity of forensic

processes but also increases the risk of contamination, misinterpretation, and ultimately, the rejection of forensic evidence in court proceedings.

4.3 Judicial Reliance on Reports Without Cross-Examination

While Indian criminal procedure permits expert reports to be admitted as evidence under Section 293 of the Code of Criminal Procedure, 1973, courts often accept these reports without summoning the forensic expert for cross-examination. Although this practice may expedite trials, it raises serious due process concerns, especially in cases involving severe penalties. Forensic reports—such as those involving DNA or toxicology—may contain technical interpretations that demand adversarial scrutiny. In *Santosh Kumar Singh v. State through CBI,* 2010, the Supreme Court affirmed the admissibility of expert reports under Section 293.

In *Navin Laxman Tamboli v. State of Maharashtra,* 2018, the Bombay High Court noted that trial courts must exercise their authority under Section 311 CrPC to summon forensic experts when the defense contests the report, particularly in serious criminal cases. Similarly, the Rajasthan High Court in *Abid Beig v. State of Rajasthan,* 2011 expressed concern over the procedural failure to supply forensic reports to the accused at the stage of their examination under Section 313 CrPC, thereby denying them a fair opportunity to respond.

These judgments reflect growing judicial awareness of the potential risks of relying on expert evidence without adversarial testing. However, systemic barriers, including limited forensic infrastructure, shortage of trained experts, and overloaded court dockets, continue to result in routine admission of forensic reports without cross-examination. This undermines the integrity of evidentiary standards and weakens the procedural fairness guaranteed under Article 21 of the Constitution.

4.4 Examples of Miscarriages of Justice Due to Flawed Forensic Practices

Numerous instances across India demonstrate how flawed forensic practices have contributed to judicial errors and miscarriages of justice. These examples underscore the urgent need for procedural reforms, professional accountability, and robust oversight in forensic science.

One of the most well-documented cases is the *Shopian rape and murder case* (2009), where two women were found dead under suspicious circumstances in Jammu & Kashmir. The Central Bureau of Investigation (CBI) later revealed that the vaginal swab samples submitted during the forensic examination were fabricated. Medical personnel had allegedly used samples from discarded slides, rather than those collected from the victims, which seriously undermined the investigation and led to criminal proceedings against the responsible staff (The Hindu, 2009).

Similarly, in the *Aarushi–Hemraj double murder case* (2008), crucial DNA evidence was mishandled. The Central Forensic Science Laboratory (CFSL) expert testified that vaginal swabs taken from the crime scene were contaminated, resulting in inconclusive results. The absence of reliable forensic support created ambiguity and contributed to conflicting judicial outcomes in a highly scrutinized trial (India Today, 2013).

The *Malegaon blast case* (2006) also highlights concerns about the reliability of forensic practices. Early forensic findings were contradicted by subsequent reports from the National Investigation Agency (NIA), which questioned the presence of RDX in the collected samples. The forensic discrepancies played a role in the eventual acquittal of several accused individuals, with courts noting that such contradictions eroded the credibility of the prosecution's case (The Wire, 2016).

In the *Sister Abhaya murder* case (2007), a post-mortem report was found to be tampered with—white correction fluid had been used to overwrite findings in the chemical examination report of vaginal swabs and smears. These manipulations raised serious questions about the integrity of the forensic investigation and significantly delayed the delivery of justice (New Indian Express, 2007).

The *Dharam Deo Yadav v. State of Uttar Pradesh* (2014) case further illustrates the problem of flawed forensic procedures. The Supreme Court found that the DNA analysis relied on by the prosecution was not scientifically credible, as it had been outsourced to a foreign lab without appropriate verification or adherence to evidentiary standards. The Court ruled that DNA evidence must be handled rigorously and verified through proper technical processes.

Institutional irregularities have also been observed. In 2018, the Delhi High Court ordered a CBI investigation into alleged irregularities at the Rohini Forensic Science Laboratory, which had been implicated in cases involving the manipulation or inaccuracy of DNA reports in sexual offence cases. The Court expressed concern that such flaws could allow the guilty to evade punishment while undermining public confidence in forensic science (The Times of India, 2018).

These examples reflect systemic issues in India's forensic ecosystem—ranging from evidence tampering and contamination to institutional failure and inadequate procedural safeguards. Together, they underscore the pressing need for enhanced regulation, improved training, and strict adherence to forensic protocols.

5. ETHICAL AND CONSTITUTIONAL CONCERNS

The growing integration of DNA technology into India's criminal justice framework has prompted significant constitutional and ethical scrutiny. While DNA profiling offers scientific precision for criminal identification and investigation, it involves the collection and long-term storage of deeply personal genetic information. Without robust legal safeguards, this raises concerns regarding bodily autonomy, privacy, consent, and the potential for misuse of sensitive data.

5.1 Privacy and Data Protection

A pivotal development in Indian constitutional jurisprudence occurred with the Supreme Court's decision in *Justice K.S. Puttaswamy (Retd.) v. Union of India,* 2017, where the Court unanimously recognized the right to privacy as a fundamental right under Article 21 of the Constitution. The Court also laid down a three-fold test to justify state interference with privacy: legality, the necessity of a legitimate aim, and proportionality, i.e., using the least intrusive method.

The DNA Technology (Use and Application) Regulation Bill, 2019, aimed to establish national and regional DNA data banks. It permitted the collection of DNA from a broad range of individuals, not only convicted criminals but also suspects, undertrials, missing persons, and unidentified bodies. Notably, consent was not mandated in all cases, especially during criminal investigations or when approved by a magistrate (PRS Legislative Research, 2019).

Civil society organizations and policy researchers expressed deep concerns about the Bill's implications for individual rights. The Centre for Internet and Society (CIS), in its critique, warned that the Bill lacked sufficient checks against potential misuse and failed to establish clear limitations on the use and retention of DNA profiles (CIS, 2015). The Bill also allowed DNA to be used for civil matters, including parentage determination and identification of missing persons, without requiring renewed consent, raising red flags about potential violations of the data minimization principle (PRS Legislative Research, 2019).

The Parliamentary Standing Committee reviewing the Bill echoed these concerns. It criticized the absence of an independent regulatory body and highlighted the potential misuse of DNA profiling for caste or community-based surveillance. The Committee also noted that the Bill granted broad discretionary powers to the proposed DNA Regulatory Board without adequate accountability (PRS Legislative Research, 2019).

Adding to these apprehensions was the lack of a comprehensive data protection law in India at the time. The Justice B.N. Srikrishna Committee (2018), which drafted a data protection framework for India, underscored the need for stronger protections for sensitive personal data, including biometric and genetic information. The Committee emphasized principles such as informed consent, purpose limitation, and the right to be forgotten. Without these protections in place, legal experts argued that the DNA Bill could enable disproportionate state surveillance and genetic discrimination, particularly affecting vulnerable groups such as minorities and underrepresented communities (The Hindu BusinessLine, 2019; Drishti IAS, 2019).

Given the constitutional standards established in *Puttaswamy*, any framework for DNA profiling must be narrowly tailored, include explicit consent protocols, ensure independent oversight, and respect the individual's right to informational self-determination.

5.2 Informed Consent and Autonomy

The principle of informed consent is a foundational element in both bioethics and legal jurisprudence, serving as a critical safeguard for individual autonomy and bodily integrity. In the realm of forensic science, particularly in DNA profiling, the ethical implications of consent are magnified due to the uniquely sensitive and personal nature of genetic data. DNA samples can reveal not only an individual's identity but also familial relationships and other biological characteristics, thereby necessitating robust procedural protections.

The DNA Technology (Use and Application) Regulation Bill, 2019 has been at the center of debate regarding its adequacy in protecting the right to consent. Crucially, it allows for the collection of DNA without the individual's consent in several instances, particularly in criminal investigations, subject to a magistrate's order (PRS Legislative Research, 2019). The Bill does not explicitly address whether consent must be documented, whether individuals can withdraw their consent or the nature of counseling—if any—required prior to collection. Such legislative ambiguity raises significant concerns under the framework of constitutional rights.

Judicial precedent in India offers critical insights into the constitutional dimensions of informed consent in forensic procedures. In *Selvi v. State of Karnataka,* 2010, the Supreme Court held that any forensic technique involving bodily intrusion must meet constitutional standards, including the requirement of voluntary and informed consent.

The constitutional concerns surrounding consent in DNA profiling are further informed by the landmark ruling in *Justice K.S. Puttaswamy (Retd.) v. Union of India*, 2017, the Supreme Court established a three-pronged test to assess any state action that infringes on privacy: it must be backed by law, pursue a legitimate state aim, and be proportionate to that aim. Applying this framework to the 2019 DNA Bill reveals several areas of concern, particularly with respect to proportionality and the use of the least intrusive means.

Moreover, the absence of a comprehensive data protection regime in India compounds the risks associated with the non-consensual collection and long-term storage of DNA data. The Justice B.N. Srikrishna Committee, in its 2018 report on data protection, emphasized that sensitive personal data, such as genetic information,

must be collected and processed with informed consent, and subject to principles such as purpose limitation and data minimization (Srikrishna Committee, 2018).
Taken together, these legal and ethical frameworks underscore the imperative of integrating stringent consent requirements within any legislative regime governing DNA profiling. In the absence of such safeguards, the collection and use of genetic material may amount to an unconstitutional intrusion on personal liberty and privacy.

5.3 International Jurisprudence on DNA and Privacy

The use of DNA technology in criminal justice systems has prompted judicial scrutiny across jurisdictions, emphasizing the need for ethical safeguards. In *S. and Marper v. United Kingdom,* 2008, the European Court of Human Rights (ECHR) found that the indefinite retention of DNA profiles and fingerprints of unconvicted individuals violated Article 8 of the European Convention on Human Rights, which guarantees the right to privacy. The Court deemed the UK's indiscriminate retention policy disproportionate and emphasized the importance of legal safeguards such as time limits, individualized review, and mechanisms for data destruction (Human Rights Law Centre, 2008; UK Parliament, 2009). Similarly, in *Maryland v. King,* 2013, the United States Supreme Court upheld the constitutionality of collecting DNA from individuals arrested for serious offenses, likening it to fingerprinting under the Fourth Amendment. However, in his dissent, Justice Scalia highlighted that, unlike fingerprints, DNA carries deeply personal genetic information, raising concerns about potential misuse and long-term retention (Wired, 2013). These cases illustrate a global consensus on the importance of proportionality, oversight, and privacy safeguards in DNA data collection and retention. They provide instructive benchmarks for India, underscoring that the deployment of DNA profiling must be narrowly tailored and constitutionally compliant.

5.4 Constitutional Accountability in India

Given India's constitutional framework and the jurisprudence affirming the right to privacy, the absence of a comprehensive statutory regime regulating DNA collection and use constitutes a significant legal and ethical gap. The Supreme Court's judgment in *Justice K.S. Puttaswamy (Retd.) v. Union of India,* 2017 established a three-part test of legality, necessity, and proportionality for any state action that infringes on privacy. These principles are especially pertinent when dealing with biometric and genetic data, which are inherently sensitive and capable of revealing intimate personal and familial information (Chandrachud, 2017).
The DNA Technology (Use and Application) Regulation Bill, 2019 raised concerns among civil society organizations and legal scholars regarding insufficient safeguards for consent, data retention, and misuse prevention (PRS Legislative Research, 2019; Centre for Internet and Society [CIS], 2019). These concerns were compounded by the absence of a broader data protection law. The Personal Data Protection Bill, 2019, introduced in Parliament to regulate sensitive personal data, including genetic and biometric information, also remained pending.
Given this legislative vacuum, legal commentators have emphasized that any deployment of DNA technologies by state agencies should align with the constitutional principles of autonomy, dignity, and proportionality (CIS, 2019; Choudhury, 2018). While courts have not explicitly ruled on DNA profiling post-*Puttaswamy*, the application of its doctrinal framework implies that DNA collection and storage, particularly without robust consent mechanisms or oversight, could pose serious constitutional risks.

6. ANALYSIS AND REFORM PROPOSALS

DNA evidence has significantly enhanced the evidentiary standards in criminal justice systems globally, offering a scientifically grounded method to establish identity, corroborate testimonies, and connect suspects to crime scenes. In India, judicial recognition of its probative value has grown over the years. For instance, in *Krishna Kumar Malik v. State of Haryana,* 2011, the Supreme Court emphasized the importance of collecting DNA evidence in cases of sexual assault, noting that post-2006 amendments to the Criminal Procedure Code (Section 53A) make it obligatory for investigating officers to collect biological samples to facilitate forensic testing. The Court criticized the investigative failure to submit semen samples for forensic examination, underlining the relevance of DNA in corroborating the survivor's testimony.

However, while DNA evidence is often perceived as conclusive, its increasing use has raised concerns about overreliance. Scholars have warned of the "CSI effect," a phenomenon where courts and jurors may give undue weight to forensic evidence, assuming it to be infallible (Saks & Koehler, 2005). This may lead to inadequate scrutiny of scientific procedures, such as sample contamination or interpretive limitations, particularly when expert testimony is unchallenged or when defense counsel lacks the technical training to contest it effectively. As Edmond (2015) argues, this judicial overconfidence in forensic technologies can undermine due process and increase the risk of wrongful convictions.

Key Areas for Reform

Enacting a Comprehensive DNA Law

India currently lacks a dedicated legal framework governing the use of DNA technology within the criminal justice system. To address this regulatory vacuum, the DNA Technology (Use and Application) Regulation Bill, 2019 was introduced in Parliament. The Bill seeks to provide statutory authority for the collection, storage, and use of DNA profiles and establishes national and regional DNA databanks, alongside a DNA Regulatory Board for oversight (PRS Legislative Research, 2019). While it aims to support forensic investigations, the Bill has drawn criticism for insufficient safeguards to protect fundamental rights, particularly in light of the Supreme Court's recognition of the right to privacy as a fundamental right in *Justice K.S. Puttaswamy v. Union of India,* 2017.

Concerns raised by legal researchers and civil society organizations focus on the Bill's lack of clear provisions on informed consent, purpose limitation, data minimization, and proportionality—principles that are now central to any data governance regime (Centre for Internet and Society [CIS], 2019; Newsclick, 2019). The absence of restrictions on the retention period for DNA data, and the allowance for civil usage without renewed consent, further amplifies the risk of state overreach and potential misuse, especially given the lack of a comprehensive data protection law as of 2020. Legal experts argue that any DNA regulatory framework must align with constitutional protections under Articles 20(3) and 21, ensuring individual rights are upheld through adequate judicial oversight and institutional accountability (CIS, 2019).

Accreditation and Oversight of Forensic Laboratories

The probative value of DNA evidence depends significantly on the procedural integrity and technical standards upheld within forensic laboratories. However, many forensic science laboratories (FSLs) in India operate without accreditation under international quality benchmarks such as ISO/IEC 17025, which governs laboratory competence in testing and calibration. According to *ThePrint* (2019), only 10 of 117 government-run FSLs in India had received accreditation from the National Accreditation Board for Testing and Calibration Laboratories (NABL) as of 2019, highlighting systemic gaps in forensic quality control.

Accreditation is a fundamental prerequisite for ensuring consistency, reliability, and legal admissibility of forensic outputs. NABL, operating under the Department of Science and Technology, applies ISO/IEC 17025 standards to assess the technical and managerial competence of laboratories, including those handling forensic evidence. In this context, mandatory accreditation and routine audits can serve as institutional safeguards against procedural lapses, backlog-induced delays, and compromised evidentiary quality.

Mandatory Cross-Examination of Forensic Experts

India's Code of Criminal Procedure (CrPC), under Section 293(2), permits courts to admit expert reports from government scientific analysts without mandating oral testimony. While intended to expedite proceedings, this practice can impede the adversarial testing of crucial forensic evidence. Courts are authorized under Section 311 of the CrPC to summon and examine any person as a witness if it appears essential to the just decision of the case.

Judicial precedent has underscored the necessity of summoning forensic experts when reports are disputed. For instance, in *Navin Laxman Tamboli v. State of Maharashtra,* 2018, the Bombay High Court held that courts must summon forensic experts where the defense contests their findings, especially in serious criminal trials. This reinforces that expert reports cannot be treated as infallible without subjecting them to adversarial scrutiny and cross-examination.

Capacity Building Among Legal Professionals

Although DNA technology holds the potential to improve accuracy in criminal adjudication, its scientific complexity often surpasses the training received by many legal professionals in India. The gap in scientific literacy among judges and lawyers has been identified in policy analyses, including by Project 39A at National Law University, Delhi. Legal actors may misinterpret probabilistic conclusions or defer uncritically to forensic testimony, leading to over-reliance on expert evidence without adequate evaluation.

To bridge this competence gap, legal education must integrate modules on forensic methodology, error rates, and evidentiary interpretation. Judicial academies and law schools should introduce foundational courses on forensic science while continuing legal education (CLE) programs can offer periodic training for practicing professionals. Such initiatives would promote informed judicial reasoning and safeguard against miscarriages of justice arising from misused or misunderstood scientific evidence.

Ensuring Independent Forensic Access for the Defense

A major structural limitation in India's forensic regime is the concentration of forensic services within state-run laboratories, which often function under the administrative control of investigating agencies. This raises concerns about institutional impartiality and limits the defense's ability to independently verify or contest forensic conclusions. Although not mandated by law, legal and policy advocates have proposed mechanisms to allow defense teams—particularly those representing indigent accused—to access accredited private forensic experts through public funding schemes or judicial authorization.

This proposal aligns with the principle of parity of arms, essential to a fair trial under Article 21 of the Indian Constitution. By institutionalizing access to independent forensic analysis, courts can ensure that scientific evidence does not become a prosecutorial monopoly but rather remains subject to balanced scrutiny.

7. CONCLUSION

The integration of DNA technology into India's criminal justice framework holds immense promise for enhancing the accuracy and integrity of the evidentiary process. Its ability to precisely identify individuals makes it a critical tool for both convicting the guilty and exonerating the innocent, particularly in cases involving heinous crimes such as rape and murder. However, the rapid expansion of forensic and DNA use must be tempered by a robust legal framework that ensures procedural fairness, safeguards individual rights, and maintains scientific credibility.

As this paper has demonstrated, the existing legal and institutional ecosystem, particularly as represented by the DNA Technology (Use and Application) Regulation Bill, 2019, remains deficient in several key areas. The Bill lacks clarity on consent protocols, fails to adequately define the limits of DNA data usage, and permits extensive profiling without sufficient oversight. These shortcomings raise serious concerns under the constitutional standards established in *Justice K.S. Puttaswamy v. Union of India,* 2017, which mandate that any state action involving personal data must satisfy the tests of legality, necessity, and proportionality.

Moreover, systemic issues—such as under-resourced forensic laboratories, the absence of standard operating procedures, and the limited scientific literacy among judicial actors—threaten the reliability and fairness of forensic evidence in practice. The courtroom's over-reliance on forensic reports, often accepted without cross-examination or technical scrutiny, further undermines the adversarial structure of criminal trials and the right to a fair defence.

Going forward, India must adopt a holistic reform approach. This includes enacting a comprehensive, rights-respecting DNA law grounded in constitutional principles; modernizing forensic infrastructure; mandating judicial and legal training in scientific methods; ensuring access to independent forensic experts for the defence; and creating strong oversight mechanisms for data protection and accountability.

Ultimately, the use of DNA and forensic science in criminal justice must be situated within a legal regime that prioritizes transparency, proportionality, and respect for fundamental rights. As technological capabilities evolve, so too must the legal safeguards that govern them. Only then can DNA evidence serve as a true instrument of justice, reinforcing the rule of law while protecting individual liberties.

REFERENCES

1. *Aarushi murder case verdict: 'Forensic tests showed Talwars were innocent'*. (2017, October 13). *The Indian Express*. Retrieved from https://indianexpress.com/
2. Abid Beig v. State of Rajasthan, 2011 (1) CrLR (Raj.) 502 (Rajasthan High Court).
3. Anvar P.V. v. P.K. Basheer, (2014) 10 SCC 473.
4. APN News. (2019, September 8). *Delhi Forensic Science Lab in Rohini gets NABL accreditation*. Retrieved from https://www.apnnews.com
5. Bandyopadhyay, T. (2010). Forensic DNA analysis: Legal and ethical concerns in the Indian context. *Indian Journal of Medical Ethics, 7*(4), 240–243. https://doi.org/10.20529/IJME.2010.079
6. Business Standard. (2019, September 8). *Forensic Science Laboratory in Delhi gets NABL accreditation*. Retrieved from https://www.business-standard.com
7. Centre for Internet and Society. (2013). *Justice delayed: The troubled state of DNA evidence in India*. https://cis-india.org/internet-governance/blog/dna-technology-bill-analysis
8. Committee of Experts under the Chairmanship of Justice B.N. Srikrishna. (2018). *A free and fair digital economy: Protecting privacy, empowering Indians*. Ministry of Electronics and Information Technology, Government of India. Retrieved from https://meity.gov.in/writereaddata/files/Data_Protection_Committee_Report.pdf
9. Comptroller and Auditor General of India. (2016). *Performance Audit Report on Modernisation of Police Force and Forensic Science Laboratories in Uttar Pradesh (Report No. 4 of 2016)*. Retrieved from https://cag.gov.in
10. Constitution of India, Articles 20 and 21. *Government of India*. Retrieved from https://indiankanoon.org/doc/1766147/ (Article 20) and https://indiankanoon.org/doc/1199182/ (Article 21)
11. Criminal Procedure Code, No. 2 of 1974, Ss 53, 53A, 164A. (India).
12. Das Gupta, M. (2018, April 26). Over 12,000 sexual assault cases pending due to backlog at forensic labs. *Hindustan Times*. Retrieved from https://www.hindustantimes.com
13. Dharam Deo Yadav v. State of U.P., (2014). *Criminal Appeal No. 268 of 2014*, Supreme Court of India.
14. Dr. Nupur Talwar v. Central Bureau of Investigation, (2012). *Supreme Court of India*. Retrieved from https://indiankanoon.org/doc/120974464/

15. Drishti IAS. (2019). *DNA Technology (Use and Application) Regulation Bill*. Retrieved from https://www.drishtiias.com/daily-updates/daily-news-analysis/dna-technology-use-and-application-regulation-bill
16. Edmond, G. (2015). What lawyers should know about the forensic 'sciences'. *Adelaide Law Review, 36*(1), 33–82.
17. Government of Himachal Pradesh. (2019). *Annual Administrative Report 2018–2019: State Forensic Science Laboratory*. Shimla: Home Department.
18. Gupta, R. (2020). Forensic genetics and privacy in India: The need for legislation. *NUJS Law Review*, 13(2), 101–118.
19. Harjinder Kaur v. State of Punjab, SCC OnLine P&H 14201 (2012).
20. Indian Evidence Act, No. 1 of 1872, Ss 45 & 65B. (India).
21. Internet Freedom Foundation. (2019). *The DNA Bill and Privacy*. Retrieved from https://internetfreedom.in/the-dna-bill-and-privacy/
22. Jagroop Singh v. State of Punjab, (2012). *Punjab and Haryana High Court*. Retrieved from https://indiankanoon.org/doc/24623476/
23. Justice K.S. Puttaswamy (Retd.) v. Union of India, (2017) 10 SCC 1.
24. Kakodkar, P. (2017, August 22). 18% forensic samples lying untested for want of staff, CAG rules. *The Times of India*. Retrieved from https://timesofindia.indiatimes.com
25. Kaur, A., & Reddy, B. (2020). DNA forensics in the Indian criminal justice system: Challenges and potential. *Indian Journal of Criminology and Forensic Science, 11*(2), 101–116.
26. Krishna Kumar Malik v. State of Haryana, (2011) 7 SCC 130.
27. Kumar, A., & Singh, P. (2019). DNA profiling and privacy concerns: A legal perspective. *Indian Bar Review*, 46(4), 45–61.
28. Kumar, R., & Singh, A. (2019). DNA profiling in criminal investigation: Legal admissibility and constitutional implications. *Indian Bar Review, 46*(4), 49–67.
29. Law Commission of India. (2005). *185th report on review of the Indian Evidence Act, 1872*. Government of India. https://lawcommissionofindia.nic.in/reports/185thReport-PartI.pdf
30. Mukesh & Anr v. State (NCT of Delhi), (2017) 6 SCC 1.
31. Musheer Khan v. State of Madhya Pradesh, (2010) 2 SCC 748.
32. NABL. (n.d.). *Accreditation criteria and process*. National Accreditation Board for Testing and Calibration Laboratories. https://nabl-india.org
33. Narayan, S., & Raghavan, V. (2020). DNA evidence and human rights: A review of judicial trends in India. *National Law School Journal*, 13(1), 47–67.
34. National Research Council. (2009). *Strengthening forensic science in the United States: A path forward*. National Academies Press. https://doi.org/10.17226/12589
35. Navin Laxman Tamboli v. State of Maharashtra, Criminal Appeal No. 1287 of 2017, Bombay High Court (2018).
36. New Indian Express. (2007, July 23). *Sister Abhaya case: Chemical report tampered with*. Retrieved from https://www.newindianexpress.com
37. Newsclick. (2019, July 27). *DNA Bill: Need for robust privacy safeguards*. Retrieved from https://www.newsclick.in/DNA-Bill-Need-Robust-Privacy-Safeguards
38. Paliath, S. (2023, August 22). What really is holding back forensic science in India? *The Wire Science*. Retrieved from https://science.thewire.in
39. Project 39A. (n.d.). *Death penalty India report* and forensic reform research. National Law University Delhi. https://www.project39a.com/
40. PRS Legislative Research. (2019). *The DNA Technology (Use and Application) Regulation Bill, 2019*. Retrieved from https://prsindia.org/billtrack/the-dna-technology-use-and-application-regulation-bill-2019
41. PTI. (2019, September 8). Forensic Science Lab in Rohini gets NABL accreditation. *India Today*. Retrieved from https://www.indiatoday.in
42. Raj, D., & Menon, A. (2018). Scientific techniques and constitutional protections: A study of Selvi and beyond. *Indian Constitutional Law Review, 6*(2), 137–152.
43. S. and Marper v. United Kingdom (ECHR, 2008*)*. Retrieved from https://www.hrlc.org.au/human-rights-case-summaries/s-and-marper-v-united-kingdom-2008-echr-3056204-grand-chamber-4-december-2008
44. Saks, M. J., & Koehler, J. J. (2005). The coming paradigm shift in forensic identification science. *Science, 309*(5736), 892–895. https://doi.org/10.1126/science.1111565
45. Santokh Singh v. State of Punjab, (2001) 4 SCC 125.
46. Santosh Kumar Singh v. State through CBI, (2010) 9 SCC 747.
47. Selvi & Ors. v. State of Karnataka, (2010) 7 SCC 263 (India).
48. Sharma, V., & Kumar, M. (2019). Quality management in Indian forensic laboratories: Need for reform. *Journal of Forensic Sciences and Criminal Investigation, 10*(2), 1–6.
49. Singh, K. P. (2018, July 17). Long wait at Delhi's forensic labs leading to rising backlog of police cases. *Hindustan Times*. Retrieved from https://www.hindustantimes.com

50. State of Himachal Pradesh v. Rajiv Jassi, (2016) SCC OnLine HP 1571.
51. State of Maharashtra v. Damu, (2000) 6 SCC 269.
52. State of Rajasthan v. Kashi Ram, (2006) 12 SCC 254.
53. The Hindu BusinessLine. (2019, July 20). *DNA profiling Bill must be reworked*. Retrieved from https://www.thehindubusinessline.com/opinion/editorial/dna-profiling-bill-must-be-reworked/article28608044.ece
54. The Hindu. (2009, December 15). *CBI chargesheet in Shopian rape case highlights forensic lapses*. Retrieved from https://www.thehindu.com
55. The Times of India. (2018, August 3). *Delhi HC seeks CBI probe into DNA lab irregularities*. Retrieved from https://timesofindia.indiatimes.com
56. The Wire. (2016, December 28). *Malegaon blast: Conflicting forensic reports cast doubt on prosecution*. Retrieved from https://thewire.in
57. ThePrint. (2019, December 18). Only 10 of 117 forensic labs in India accredited, SC pulls up govt. *ThePrint*. https://theprint.in/india/only-10-of-117-forensic-labs-in-india-accredited-sc-pulls-up-govt/338090/
58. Thomson Reuters Foundation. (2018, November). *India's DNA backlog: Forensic failures and judicial delays*. Retrieved from https://news.trust.org
59. Tribune. (2019, November 27). Junga forensic lab gets NABL accreditation. *The Tribune*. Retrieved from https://www.tribuneindia.com
60. UK Parliament. (2009). *Explanatory Notes: Crime and Security Bill 2009–10*. Retrieved from https://publications.parliament.uk/pa/ld200910/ldbills/045/en/10045x-d.htm
61. Wired. (2013). *Supreme Court OKs Taking DNA From Arrestees*. Retrieved from https://www.wired.com/2013/06/scotus-dna-testing