
THE INFLUENCE OF DNA TECHNOLOGY ADVANCEMENTS ON CRIMINAL INVESTIGATIONS: REVOLUTIONIZING FORENSIC PRACTICES AND SHAPING LEGAL OUTCOMES

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ABSTRACT

DNA profiling is a technique employed to determine an individual's identity at a molecular level. In recent years, the use of DNA evidence in criminal investigations has seen a substantial rise. DNA testing has played a crucial role in aiding law enforcement agencies in identifying criminals and solving complex cases, including rape, murder, and sexual assault. The ability of DNA typing has played a crucial role in resolving immigration problems and complicated paternity cases when the father is not present. The rapid identification of individuals in mass disasters using DNA typing has been made possible, and computerized DNA databases for tracking criminal offenders have been set up in certain countries. DNA is an invaluable investigative tool because, except for identical twins, no two individuals have the exact same DNA. In essence, the sequence of nucleotides in the cell's DNA differs in specific regions, leading to the distinctiveness of each person's genetic makeup. Without a doubt, DNA plays a vital role in criminal investigations, particularly in cases involving murder, sexual assault, disputed paternity, and man-made disasters. This paper delves into the scientific principles behind DNA identification and its practical use in criminal investigations, trials, appeals, and post-conviction procedures. It highlights the main benefits and drawbacks of the increasing importance of DNA identification in the criminal justice system, with a specific focus on India. We believe that the obstacles presented by DNA technologies will be resolved in the future.

The main idea of the paragraph is that the author is trying to persuade the reader to accept their argument by using rhetorical devices and logical appeals.

Forensic science plays a crucial role in the criminal justice system, serving as a link between scientific discoveries and legal proceedings. Forensic science encompasses a wide range of scientific disciplines, including DNA

analysis, toxicology, pathological studies, and ballistics, which are all essential for investigating and uncovering illegal activities. Over the years, these fields have undergone significant changes, offering law enforcement and the courts with reliable methods to gather evidence and address matters. In recent years, the utilization of DNA (deoxyribonucleic acid) evidence has significantly transformed criminal investigations worldwide. Despite the numerous challenges faced by India's criminal justice system, DNA evidence has become a crucial tool in accurately determining guilt or innocence. This study delves into the profound influence of DNA evidence in criminal cases in India, highlighting its importance in improving investigative methods, guaranteeing fairness in the legal system, and overcoming the challenges of establishing guilt beyond a reasonable doubt. The study aims to elucidate how DNA evidence not only assists in identifying and prosecuting offenders but also contributes to broader discussions on justice and human rights within the Indian legal framework by investigating its legal, procedural, and ethical dimensions.

Historical development of DNA evidence in India.

The origins of DNA evidence in India can be traced back to the mid-1980s, with the introduction of the restriction fragment length polymorphism (RFLP) technique. This technique enabled researchers to identify distinctive patterns in an individual's DNA, akin to a fingerprint, for the purpose of identification.

In the 1990s, the polymerase chain reaction (PCR) technology emerged as the primary method for DNA testing in India. This technique facilitated the rapid amplification of DNA samples, greatly enhancing the utilization of DNA evidence in criminal investigations. In 1988, researchers at the centre for cellular and molecular biology (CCMB) in India made significant progress by developing their own DNA fingerprinting probes, establishing India as the third country globally to create this groundbreaking technology. These probes were presented as evidence in a paternity case that was heard by the Kerala High Court in 1991, making it the first time that DNA evidence was accepted in an Indian court. Since its inception, DNA fingerprinting has seen extensive application in India for various reasons, including the identification of individuals implicated in criminal cases like murder, sexual assault, and targeted killings, alongside determining paternity, resolving family disputes, and identifying missing persons and unidentified bodies. In order to promote the growing reliance on DNA evidence, the centre for DNA fingerprinting and diagnostics (cdfd) was established as an autonomous organization by the department of biotechnology, government of India. Although

DNA evidence is now widely accepted in Indian courts, there are still several obstacles to overcome. These challenges encompass the absence of clear guidelines regarding the collection of samples, the storage of data, and the protection of privacy. Additionally, DNA evidence is often seen as supplementary rather than definitive proof, and its use in establishing the innocence of suspects and convicts is limited. In order to tackle these concerns, India is currently working on formulating the DNA technology (use and application) regulation bill. The proposed legislation seeks to establish a regulatory board responsible for creating guidelines and standards for DNA testing laboratories and data banks. The passage of this legislation is expected to enhance the utilization of DNA evidence within the indigenous legal framework, thereby optimizing its effectiveness in criminal investigations and wrongful conviction reversals.

The concept of DNA profiling

Deoxyribonucleic acid (DNA) is the genetic material found in the cells of all living organisms. Every individual possesses a distinct DNA profile, which is indistinguishable from that of identical twins. Alec Jeffreys, a geneticist from Leicester University in England, is renowned for his development of the DNA profiling method. DNA profiling is a contemporary genetic method employed by forensic experts to establish an individual's identity. This approach entails examining human DNA obtained from diverse sources, such as saliva, skin, hair, blood, and sperm. The obtained DNA can be compared with samples taken from a specific individual who has already been identified. It aids in recognizing personality traits, behaviors, and occasionally, genetic disorders in an individual. For severe crimes such as murder and sexual assault, technological progress has made it possible to identify individuals from tiny tissue samples. It is also employed in legal settings, particularly in instances where familial connections need to be established.

The legal framework of India in relation to DNA technology

Although India does not have specific laws governing the use and application of DNA testing in the justice system, it is still considered as evidence in various procedural and substantive laws, similar to many developed nations.

Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS)

The Bharatiya Nagarik Suraksha Sanhita, 2023 has updated its criminal investigation

procedures. This legislation places a strong emphasis on enhancing forensic techniques and is motivated by advancements in technology and law enforcement. The fundamental components of forensic science comprise:

- **Obligation to utilize scientific evidence:** the BNSS mandates the incorporation of forensic evidence in serious criminal investigations to provide scientific support
 - **Strengthened chain of custody standards:** The law implements stringent guidelines to protect against tampering with scientific samples, such as DNA and digital evidence
 - **The collection of electronic evidence** includes a set of guidelines that outline the proper methods for obtaining and examining digital evidence, with a focus on using accredited forensic laboratories to ensure the integrity of the evidence.
 - **Creation of specialized forensic units:** encourages the establishment of investigative teams within police departments to expedite evidence collection and analysis
- **Section 51** permits law enforcement to ask a medical professional to examine the accused, including the collection of DNA samples

Section 184 of the law requires that individuals who have been victims of rape undergo a mandatory medical examination, which includes collecting forensic evidence such as DNA samples to establish the occurrence of the crime and identify the perpetrator.

Bharatiya Sakshya Adhiniyam 2023 (BSA).

The Bharatiya Sakshya Adhiniyam, 2023, establishes the credibility and acceptability of evidence presented in court, specifically in relation to forensic evidence. Important provisions comprise:

- **Recognition of modern forensic techniques:** Expands the types of evidence that can be admitted to include findings from modern forensic methods.
- **Validation of digital evidence:** To ensure compliance with recognized forensic standards, the act introduces specific regulations for the identification of digital and electronic evidence.

o Simplifying the testimony of experts: It codifies the process for presenting forensic expert testimony, requiring thorough explanations of methods and conclusions to enhance transparency and clarity.

Safeguarding experts and witnesses: Offers protections for forensic specialists and witnesses against harm or intimidation, guaranteeing their impartial involvement in court proceedings.

- Section 9 establishes that any fact relevant to determining a person's identity is admissible, making DNA profiling pertinent as expert evidence for identity verification in line with common law principles
- Section 39 addresses expert opinions from individuals who possess specialized knowledge in foreign law, science, art, or any other field, stating that such expert opinions are relevant when the court needs to form a judgment on these matters
- Section 116 states that if a person is born during a valid marriage between their mother and a man, or within 280 days after the marriage's dissolution while the mother is still unmarried, it serves as conclusive evidence that the child is the legitimate offspring of that man, unless it can be demonstrated that the couple had no access to each other during the period when the child could have been conceived.

The document that establishes the basic principles and rules of the Indian state.

- The advent of DNA technology has presented significant challenges to various legal and personal rights, such as the "Right to Privacy" and the "Right Against Self-Incrimination" The right to privacy is encompassed within the right to life and personal liberty, as outlined in article 21 of the Indian constitution, while article 20(3) ensures the right against self-incrimination, protecting an accused individual in criminal proceedings from having to testify against themselves or provide evidence that could imply guilt. However, the supreme court has ruled multiple times that the right to life and personal liberty is not an unconditional right.

Article 51a (h) promotes the cultivation of a scientific mindset, humanism, and a curiosity-driven approach to reform.

- Article 51a (j) calls for the pursuit of excellence in all areas of individual and collective endeavor, leading the nation to consistently achieve greater heights in its efforts

- In addition, entry 65 in list i of schedule vii grants parliament the authority to legislate for the promotion of various technological and scientific methods for crime detection and to expedite the investigative process

The bill aims to regulate the use and application of DNA technology in 2019.

- The DNA technology (use and application) regulation bill, 2019, aims to govern the application of DNA technology in India for identifying missing individuals, victims, and offenders
- The bill proposes the creation of a national data bank and regional databases to manage records. It also emphasizes the importance of obtaining consent for collecting DNA samples and includes provisions for removing DNA profiles from databases under certain conditions.

This legislation seeks to enhance forensic capabilities while also addressing privacy and ethical concerns associated with DNA profiling. The DNA technology (use and application) regulation bill, 2019, outlines the features and regulations surrounding the use of DNA technology.

The main characteristics of the DNA technology (use and application) regulation bill, 2019 are:

According to the bill, DNA testing is allowed only for the matters listed in the schedule of the bill. These matters encompass offenses covered under the Indian Penal Code of 1860, as well as civil disputes like paternity cases. Furthermore, the schedule includes genetic testing that is crucial for establishing an individual's unique identity.

- **DNA collection:** When creating a DNA profile, bodily substances may be collected by law enforcement agencies. In certain situations, law enforcement officials are required to seek permission before gathering evidence. When someone is arrested, law enforcement officials must obtain written permission if the crime they are accused of could result in a sentence of up to seven years. In cases where the offence carries a potential sentence of more than seven years in prison, consent is not required. Additionally, if the individual is a victim, a relative of a missing person, or a minor or disabled person, authorities must obtain written consent from the victim, their relative, or the parent or guardian of the minor or disabled individual. In cases where consent is refused, authorities may request a magistrate's approval to collect bodily substances from individuals involved.

- DNA data bank: The proposed legislation includes the creation of a national DNA data bank and regional DNA data banks for each state or for multiple states DNA laboratories are obligated to share the genetic data they produce with national and regional DNA databases. Each data bank is required to maintain indexes for the following categories:

- (i) A crime scene index,
- (ii) An index for suspects or undertrials
- (iii) An offenders' index
- (iv) An index for missing persons
- (v) An index for unidentified deceased individuals.

The legislation specifies that the regulations will outline the criteria for entry, retention, or deletion of DNA profiles. However, it specifies that DNA profiles can be removed for the following individuals: (i) A suspect if a police report is filed or a court order is issued, (ii) An undertrial if a court order is issued, and (iii) Upon written request for those who are neither suspects nor offenders or undertrials, from the crime scene or missing persons' index.

- DNA regulatory board: The legislation calls for the formation of a DNA regulatory board, which will oversee the DNA data banks and DNA laboratories The secretary of the department of biotechnology will hold the position of ex officio chairperson of the board. The board will consist of additional members, including: (i) specialists in biological sciences, and (ii) the director general of the national investigation agency and the director of the central bureau of investigation.

- Responsibilities of the board: The responsibilities of the board include:

- (i) Providing guidance to governments on matters related to the establishment of DNA laboratories or data banks,
- (ii) Granting accreditation to DNA laboratories Furthermore, the board must ensure that all information concerning DNA profiles managed by the data banks, laboratories, and other entities remains confidential.

Any laboratory conducting DNA tests must obtain accreditation from the board. The board may revoke this accreditation for reasons such as:

- (i) Not conducting DNA testing
- (ii) Not following the conditions associated with the accreditation. In the event of accreditation revocation, an appeal can be submitted to the central government or another authority appointed by the central government. Furthermore, every DNA laboratory must adhere to quality assurance standards for the collection, storage, and analysis of DNA samples. Once the DNA profile for criminal investigations is submitted, the laboratory is obligated to send back the biological sample to the investigating officer. For all other situations, the sample must be disposed of.

• Criminal Offenses: the legislation stipulates penalties for various offenses, including:

- (i) Unauthorized disclosure of DNA information
- (ii) Using DNA samples without permission For instance, unauthorized disclosure of DNA information can lead to imprisonment of up to three years and a fine of up to one lakh rupees.

Acceptance of DNA technology in India

The reliability and trustworthiness of DNA evidence can be proven by its widespread acceptance as a dependable technique for identifying individuals worldwide. Courts are more inclined to be convinced by DNA evidence compared to other types of evidence because it represents an unchangeable biological fact. Indian courts have generally embraced the use of DNA evidence, except in cases where disputes over parental rights arise. In the case of *Sharda v. Dharmpal*, the supreme court determined that a matrimonial court has the power to order a person to undergo a medical examination, without violating article 21 of the constitution. The court emphasized that a respondent who refuses to comply with a medical examination ordered by the court may face negative consequences. Furthermore, DNA evidence was used to support the execution of the defendant in the case of *Surendra Koli v. State of Uttar Pradesh*.

The Indian Supreme Court acknowledged DNA profiling as an extremely accurate technique for identifying a suspect's DNA in samples collected from a crime scene. The court observed

that: "judicial reliance on DNA evidence has been on the rise." After the modification of the criminal procedure code through act 25 of 2005, the inclusion of section 53a has made DNA profiling a part of the legal framework. DNA evidence has become a key forensic tool for identifying offenders." in the case of *Santhosh Kumar Singh v. State through CBI*, commonly referred to as the *Priyadarshini Mattoo case*, extensive discussions regarding DNA profiling were held within both lower and higher courts. The supreme court, while upholding the conviction, emphasized that a court cannot substitute its own judgment for that of an expert, especially in scientific fields like DNA profiling, which is still in its early stages of development.

In the case of *Nandlal Wasudeo Badwaik v. Lata Nandlal Wasudeo Badwaik & Anr.*, which involved a maintenance claim, the supreme court overturned the presumption rule found in section 112 of the Indian evidence act. The statement clarified that a man cannot be legally obligated to financially support a child if scientific tests disprove the presumption of paternity. The court concluded that when the most advanced scientific techniques are accessible, placing undue weight on presumptions should not be preferred. If science provides answers, they should be employed. A three-judge panel of the hon'ble apex court, in a significant ruling, concluded that involuntary administration of polygraph and Beap tests, narco-analysis, and other scientific procedures would yield results equivalent to 'testimony,' which constitutes a violation of article 20(3). However, in *Ritesh Sinha v. State of U.P.*, the court did not concur with the argument that conducting a voice test without consent would infringe upon the individual's right against self-incrimination. In a similar situation, Hon'ble Justice Ranjana Desai stated that 'the gathering and preservation of DNA samples, similar to physical evidence, should not face any hindrances in the Indian legal system.'

In numerous significant criminal cases in India, forensic science played a crucial role in ensuring justice was served. These events illustrate how forensic techniques and tools can greatly impact the results:

- The 2012 gang rape incident in Delhi (*Nirbhaya case*): DNA profiling was crucial in identifying and convicting the perpetrators. By gathering and examining biological samples from the crime scene, the forensic team was able to compare these with the DNA profiles of the person being accused. The scientific reliability of the evidence guaranteed a swift trial and conviction, highlighting the significance of DNA analysis in serious crimes.

- The murder of Aarushi Talwar: forensic pathology, DNA testing, and fingerprint analysis were utilized in this case. Despite the controversy surrounding the investigation, it emphasized the significance of forensic methods in determining timelines and reconstructing crime scenes. This case demonstrated the negative consequences of inadequate forensic practices, such as mishandling evidence and inadequate analysis, which resulted in delays and a loss of public confidence.
- The murder case of Sheena Bora: Forensic pathology determined the cause of death, while anthropological forensics played an essential role in locating the victim's skeletal remains. This case highlighted the scarcity of sophisticated methods like skeletal analysis and isotope testing in numerous forensic laboratories, underscoring their significance.
- In *Premjibhai Bachubhai Khasiya v. State of Gujarat* (2009) The court emphasized that while a positive DNA report can significantly bolster the prosecution's case, it should not stand as the sole basis for determining the accused's guilt. It is essential to take into account such reports in conjunction with other forms of evidence to establish guilt with a high level of certainty. On the other hand, the court acknowledged that a negative DNA result holds significant weight in proving innocence. If DNA evidence does not establish a connection between the accused and the crime, it would definitively exonerate the defendant from the charges. This clarification emphasizes the importance of using DNA evidence judiciously and in conjunction with other reliable evidence to ensure fair and just outcomes in criminal cases.
- In the case of *Anil v. State of Maharashtra* (2014) The court acknowledged that when the DNA profile of a sample found at the crime scene matches that of a suspect, it usually suggests a shared biological origin. This serves as compelling evidence of the accused's participation in the criminal act. Nevertheless, the court emphasized that the accuracy of DNA evidence relies heavily on strict quality control measures and meticulous procedures carried out in the laboratory conducting the analysis. Ensuring the proper collection, preservation, and examination of DNA samples is essential to avoid contamination or degradation that could compromise the accuracy of the results. Maintaining the integrity of the entire process, from the crime scene to the courtroom, is essential to ensuring the weight and credibility of the DNA evidence presented. The court's remarks emphasize the importance of forensic laboratories following rigorous protocols and best practices to ensure the accuracy and reliability of DNA reports. This ultimately helps the judicial system in achieving fair and unbiased decisions. In

order for a DNA result to be dismissed, the court stated that it must be conclusively demonstrated that the report is flawed due to inadequacies in the quality control or assurance during the testing process. This ruling marks a significant progress in reinforcing the evidentiary value of DNA within the legal system, encouraging the implementation of scientifically sound methods to ensure fairness in the justice process.

- In the significant case of *Rahul v. State of Delhi* (2022), These concerns primarily arose from serious doubts about the methods used in collecting and sealing the samples. The focus of the case was on DNA evidence, which was questioned due to possible mishandling and a failure to adhere to proper protocols for collecting and preserving the samples, even though a match was indicated. The court highlighted the essential importance of maintaining a strict chain of custody and ensuring that samples are collected, sealed, and transferred in a manner that completely eliminates any chance of contamination or tampering. Because of the doubts surrounding the integrity of the sample processing methods, the court determined that the DNA evidence was not fully reliable. As a result of a DNA match, the court acquitted the accused. The court emphasized that the dependability of forensic evidence is of utmost importance in guaranteeing a just trial and upholding the fundamental principles of justice.

- In the case of *Manoj v. State of Madhya Pradesh* (2022) The court determined that the lack of a random occurrence ratio in the DNA analysis could raise significant doubts regarding the accuracy and reliability of the evidence. The significance of this ratio lies in its capacity to offer a statistical measure of the probability of discovering a specific DNA profile within the entire population. If the 'random match probability' is not considered, which assesses the likelihood of a DNA profile coincidentally matching someone other than the suspect, the credibility of the DNA evidence is compromised. The court stressed the importance of including this statistical probability to create a strong and scientifically sound foundation for DNA matches. This guarantees that the evidence can withstand scrutiny and serve as a reliable basis for judicial decisions.

Problems and difficulties

- Lack of standardization: one of the primary challenges confronting forensic science in India is the lack of uniformity among forensic laboratories. Many research facilities still use outdated equipment and do not follow a standardized procedure for forensic analysis. As a result, the quality of forensic evidence presented in court varies greatly. The bureau of police research

and development (BPRD) has emphasized the importance of forensic lab accreditation by bodies like the national accreditation board for testing and calibration laboratories (NABL) to ensure consistency and credibility in forensic practices.

- Delay in forensic reports:** Indian forensic labs are often overwhelmed with cases, which is exacerbated by a shortage of personnel and resources. These delays can undermine the justice system, particularly for urgent cases that rely on timely forensic evidence. The situation is exacerbated by insufficient funding and ineffective case management. In order to address these challenges, it is crucial to improve the forensic infrastructure and provide more government support.

The rapid progress in forensic science, especially in areas like computer forensics and toxicology, has resulted in a disparity between the technological requirements and the existing expertise. Due to a lack of skilled forensic experts, India continues to rely on outdated techniques. It is crucial to enhance the education and training of police and forensic personnel and to foster partnerships with educational institutions to address the increasing need for skilled forensic specialists.

- Public awareness:** In India, the general population often holds a skeptical view of forensic science, which fosters uncertainty regarding its reliability and accuracy. This lack of comprehension also impacts the legal system and law enforcement, leading to the underutilization of forensic resources. To establish trust in forensic evidence, it is essential to implement initiatives that enhance awareness, including workshops, educational programs, and training for law enforcement and judicial personnel.

Next steps

- **Standardizing Forensic Practices:** to ensure the consistency of forensic procedures nationwide, India needs a unified framework. This entails establishing uniform procedures for the gathering, safeguarding, examination, and delivery of evidence. Adhering to international standards like ISO 17025 for forensic laboratories and obtaining certification from bodies like the national accreditation board for testing and calibration laboratories (NABL) are essential initial steps. A centralized organization responsible for tracking compliance can assist in resolving inconsistencies and verifying the credibility of forensic evidence presented in court.

Integration of advanced technology: the landscape of criminal justice in India could be transformed by the adoption of advanced technologies like blockchain, deep learning, and artificial intelligence (ai) Ai and machine learning (ml) can aid in examining intricate datasets, automating monotonous forensic tasks, and improving the accuracy of DNA and fingerprint analyses. Blockchain technology can offer secure and unalterable storage and sharing of criminal records. These advancements could be integrated into forensic services through government programs like the digital India initiative.

To meet the increasing demand for forensic services, it is crucial to enhance the training and infrastructure of forensic laboratories. Collaborative specialized training programs can be set up with international forensic organizations and educational institutions. Additionally, modernizing laboratories with cutting-edge equipment such as DNA sequencers, 3d imaging systems, and advanced digital forensics software should be prioritized for government funding.

They highlight the potential for higher conviction rates and shorter trial durations. Despite these challenges, such as the absence of adequate forensic infrastructure, a shortage of trained personnel, and a lack of awareness among stakeholders, progress is being made. To tackle these challenges, the authors suggest the establishment of advanced forensic labs in various states, improving capacity building through ongoing training for law enforcement and judicial staff, and incorporating forensic education into academic programs. Additionally, public awareness campaigns are suggested to improve knowledge about forensic science's significance in the legal system, facilitating the proper implementation of the new legal frameworks.

Conclusion:

The utilization of DNA evidence in India has brought about a revolutionary change in the criminal justice system, offering indisputable scientific proof that is crucial for attaining precise verdicts. Its implementation signifies a significant change in investigative techniques, bolstering their reliability and effectiveness. Although it plays a crucial role, challenges related to logistical constraints and concerns about admissibility continue to persist. Overcoming these challenges requires focused training and the establishment of necessary infrastructure. In the future, advancements in DNA technology could result in faster analyses and larger databases. Nevertheless, it is crucial to closely monitor and regulate these developments due to ethical concerns surrounding privacy and the potential for misuse. In summary, the integration of DNA evidence has significantly influenced criminal investigations in India. Nevertheless, the

successful implementation of this policy necessitates a fair and equitable approach that upholds justice, safeguards individual rights, and prudently utilizes technological advancements.

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