

THE LAWWAY WITH LAWYERS JOURNAL

Website: www.the-lawway-with-lawyers.com

VOLUME:-35 ISSUE NO:- 35 , MAY 16, 2026

ISSN (ONLINE):- 2584-1106

Email: thelawwaywithlawyers@gmail.com

Digital Number : 2025-23534643

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DNA PROFILING IN CRIMINAL INVESTIGATION

A COMPARATIVE LEGAL ANALYSIS OF THE UNITED STATES, UNITED KINGDOM, AND INDIA

Abstract

The incorporation of scientific advancements into the criminal justice system has significantly altered the landscape of criminal investigation, shifting it from reliance on subjective methods toward objective, evidence-based approaches. Among the various forensic tools available, DNA profiling has emerged as one of the most reliable and transformative innovations in modern criminology. This research paper undertakes an extensive examination of DNA profiling, focusing on its scientific foundation, historical evolution, legal admissibility, and constitutional implications. The study adopts a comparative perspective, analyzing the legal frameworks governing DNA evidence in the United States, the United Kingdom, and India. It critically evaluates the strengths and weaknesses of each jurisdiction, particularly in relation to admissibility standards, institutional mechanisms, and the balance between individual rights and state interests. While developed jurisdictions have established comprehensive legal and regulatory systems that facilitate the effective use of DNA technology, India continues to grapple

with the absence of a unified legislative framework, resulting in inconsistencies and legal uncertainty. The paper also explores the ethical and privacy concerns associated with DNA profiling, including issues of data protection, consent, and potential misuse of genetic information. It argues that although DNA profiling enhances the accuracy and credibility of criminal investigations, its unregulated use may pose significant threats to fundamental rights. The study concludes by advocating for a robust and balanced legal framework in India that integrates scientific innovation with constitutional safeguards.

Introduction

The evolution of criminal justice systems has been closely linked to advancements in science and technology. Historically, the investigation of crimes relied heavily on traditional methods such as eyewitness testimony, confessions, and circumstantial evidence. While these methods played a significant role in early legal systems, they have increasingly been criticized for their unreliability and susceptibility to error. Eyewitness testimony, for instance, is often influenced by memory distortions, psychological bias, and external pressures, leading to inaccuracies in identification. Similarly, confessions obtained under coercion or duress raise serious concerns regarding their voluntariness and reliability. The limitations of these conventional methods have been exposed through numerous cases of wrongful convictions, highlighting the urgent need for more reliable and objective forms of evidence.

The emergence of forensic science has addressed many of these shortcomings by introducing scientific techniques into the investigative process. Forensic science provides a systematic and empirical approach to crime detection, enabling investigators to rely on physical and biological evidence rather than subjective interpretations. Among the various branches of forensic science, DNA profiling has gained unparalleled prominence due to its ability to establish identity with a high degree of precision. The uniqueness of an individual's genetic makeup makes DNA an exceptionally reliable tool for linking suspects to crime scenes, thereby enhancing the accuracy of criminal investigations.

DNA profiling has revolutionized the administration of justice by providing a means to both convict the guilty and exonerate the innocent. Its impact is particularly evident in cases involving serious offences such as murder and sexual assault, where traditional evidence may be insufficient or unreliable. Moreover, DNA technology has played a crucial role in resolving cold cases, identifying disaster victims, and establishing biological relationships in civil disputes. Despite its numerous advantages, the use of DNA profiling raises complex legal and ethical issues. The collection, storage, and analysis of genetic information involve significant implications for privacy, consent, and data protection. The potential misuse of DNA data by state authorities or private entities further complicates the issue, necessitating the development of robust legal safeguards.

This research paper seeks to examine the role of DNA profiling in criminal investigations through a comparative analysis of three jurisdictions: the United States, the United Kingdom, and India. These jurisdictions have been selected due to their distinct legal approaches and varying levels of technological advancement. The United States represents a system characterized by judicial scrutiny and evolving admissibility standards, while the United Kingdom exemplifies a statutory approach supported by extensive DNA databases. India, on the other hand, presents a developing framework with significant legal and institutional challenges. By analyzing these systems, the paper aims to identify best practices and provide recommendations for improving the legal framework governing DNA profiling in India.

Scientific Basis of DNA Profiling

The scientific foundation of DNA profiling lies in the structure and function of Deoxyribonucleic Acid, which serves as the primary carrier of genetic information in living organisms. DNA is composed of a sequence of nucleotides arranged in a double-helix structure, with each nucleotide containing a sugar, a phosphate group, and a nitrogenous base. The sequence of these bases determines an individual's genetic characteristics, making DNA a unique identifier.

One of the most significant features of DNA is its variability among individuals. While a large portion of human DNA is identical across the population, certain regions exhibit variation,

allowing for differentiation between individuals. These variable regions, known as polymorphic loci, form the basis of DNA profiling. By analyzing these loci, forensic scientists can generate a genetic profile that is highly specific to an individual.

The process of DNA profiling involves several stages, beginning with the collection of biological samples from crime scenes or individuals. These samples may include blood, saliva, hair, skin cells, or other bodily fluids. Once collected, the DNA is extracted and purified to remove contaminants. The next step involves amplification, where specific regions of the DNA are copied multiple times using techniques such as Polymerase Chain Reaction. This step is particularly important when dealing with small or degraded samples.

Following amplification, the DNA fragments are analyzed to identify patterns of variation. Modern DNA profiling primarily relies on Short Tandem Repeat analysis, which examines repetitive sequences within the DNA. These sequences vary in length among individuals, allowing for precise identification. The resulting profile is then compared with reference samples or databases to establish a match.

The evidentiary value of DNA profiling is derived from its statistical reliability. The probability of two unrelated individuals sharing the same DNA profile is extremely low, making it a highly reliable form of evidence. However, this reliability is contingent upon proper handling and analysis of samples. Errors such as contamination, degradation, or misinterpretation can compromise the accuracy of results. Therefore, strict adherence to forensic protocols and quality control measures is essential to ensure the integrity of DNA evidence.

3. Historical Evolution of DNA Profiling

The development of DNA profiling is rooted in the broader history of genetic research. The identification of DNA as the carrier of genetic information marked a significant milestone in the field of molecular biology. Early research focused on understanding the chemical composition and structure of DNA, leading to the discovery of its double-helix configuration. This discovery laid the foundation for subsequent advancements in genetic analysis.

The application of DNA in forensic science began in the late 20th century, with the pioneering work of scientists who recognized its potential for identification purposes. The first use of DNA profiling in a criminal case demonstrated its effectiveness in distinguishing between individuals, leading to its rapid adoption by law enforcement agencies. Over time, technological advancements have enhanced the accuracy, speed, and efficiency of DNA analysis, making it an indispensable tool in criminal investigations.

The establishment of DNA databases has further expanded the scope of DNA profiling. These databases allow for the storage and comparison of DNA profiles, enabling the identification of suspects and the resolution of cases that would otherwise remain unsolved. The integration of DNA technology into criminal justice systems has not only improved investigative capabilities but also contributed to the development of new legal principles and frameworks.

4. DNA Profiling in the United States

The United States has played a pioneering role in the development and integration of DNA profiling within its criminal justice system. From the early stages of forensic adoption, American courts and law enforcement agencies have recognized the immense potential of DNA evidence in enhancing the accuracy and reliability of criminal investigations. Over time, the United States has developed a sophisticated legal and institutional framework that not only facilitates the use of DNA profiling but also ensures a degree of judicial oversight in its application.

One of the defining features of the American approach to DNA evidence is the emphasis on admissibility standards. The legal system in the United States has evolved significantly in determining the conditions under which scientific evidence, including DNA profiling, may be admitted in court. Initially, the admissibility of scientific evidence was governed by the Frye standard, which required that the scientific technique in question be “generally accepted” within the relevant scientific community. While this standard provided a degree of reliability, it was criticized for being overly rigid and for potentially excluding emerging scientific methods that had not yet achieved widespread acceptance.

The shift from the Frye standard to the Daubert standard marked a transformative moment in the legal treatment of scientific evidence. Under the Daubert framework, judges assume the role of “gatekeepers,” tasked with evaluating the reliability and relevance of scientific evidence before it is presented to the jury. This involves assessing factors such as the testability of the method, its peer review status, known or potential error rates, and its general acceptance within the scientific community. The Daubert standard thus provides greater flexibility while ensuring that only scientifically valid evidence is admitted in court. This approach has significantly contributed to the widespread acceptance of DNA profiling in American courts.

In addition to judicial standards, the legislative framework in the United States has played a crucial role in regulating DNA profiling. Various statutes have been enacted to facilitate the collection, storage, and analysis of DNA samples. These laws have also addressed issues such as backlog reduction, post-conviction testing, and the establishment of DNA databases. The Combined DNA Index System, commonly known as CODIS, represents one of the most significant institutional developments in this regard. Managed by the Federal Bureau of Investigation, CODIS is a centralized database that integrates DNA profiles from convicted offenders, arrestees, and crime scene evidence. The system enables law enforcement agencies across different jurisdictions to compare DNA profiles and identify potential matches, thereby significantly enhancing investigative efficiency.

The impact of CODIS on criminal investigations has been profound. It has facilitated the resolution of numerous cold cases and has contributed to the identification of repeat offenders. Moreover, the system has played a crucial role in exonerating individuals who were wrongfully convicted, thereby reinforcing the credibility of the criminal justice system. However, the expansion of DNA databases has also raised concerns regarding privacy and the potential misuse of genetic information. The inclusion of DNA profiles from arrestees, rather than only convicted individuals, has been particularly controversial, as it raises questions about the presumption of innocence and the scope of state power.

The constitutional implications of DNA profiling in the United States are primarily examined under the Fourth Amendment, which protects individuals against unreasonable searches and seizures. The collection of DNA samples, particularly from individuals who have not been convicted of any crime, has been challenged on the grounds that it constitutes an intrusion into personal privacy. The Supreme Court's decision in *Maryland v. King* represents a landmark ruling in this context. The Court upheld the constitutionality of DNA collection from arrestees, reasoning that it is comparable to fingerprinting and serves a legitimate government interest in identifying individuals and solving crimes. While the majority opinion emphasized the practical benefits of DNA profiling, dissenting opinions raised concerns about the potential for abuse and the erosion of privacy rights.

Another important aspect of the American approach to DNA profiling is the role of post-conviction testing in addressing wrongful convictions. Organizations such as the Innocence Project have utilized DNA evidence to exonerate individuals who were convicted based on flawed or unreliable evidence. These cases have highlighted the fallibility of traditional investigative methods and have underscored the importance of scientific validation in the pursuit of justice. The availability of post-conviction DNA testing has not only provided relief to wrongfully convicted individuals but has also contributed to broader reforms in the criminal justice system.

Despite its advantages, the use of DNA profiling in the United States is not without challenges. Issues such as laboratory errors, contamination of samples, and misinterpretation of statistical data continue to pose risks to the integrity of DNA evidence. The case of *People v. Castro* serves as a notable example, where the reliability of DNA evidence was questioned due to deficiencies in laboratory procedures. This case led to the establishment of stricter quality control measures and highlighted the importance of maintaining high standards in forensic analysis.

In conclusion, the United States has developed a comprehensive and dynamic framework for the use of DNA profiling in criminal investigations. The combination of judicial scrutiny, legislative support, and institutional mechanisms has enabled the effective utilization of DNA

technology while addressing concerns related to reliability and constitutional rights. However, the ongoing debates surrounding privacy and data protection indicate that the legal framework must continue to evolve in response to emerging challenges.

5. DNA Profiling in the United Kingdom

The United Kingdom has adopted a distinct approach to DNA profiling, characterized by a strong emphasis on statutory regulation and centralized database management. Unlike the United States, where judicial scrutiny plays a central role in determining the admissibility of scientific evidence, the UK legal system relies primarily on legislative enactments to define the scope and application of DNA technology in criminal investigations. This approach reflects a policy-driven framework that prioritizes efficiency and administrative control while incorporating safeguards to protect individual rights.

The development of DNA profiling in the United Kingdom has been closely linked to legislative reforms that have progressively expanded the powers of law enforcement agencies. Early statutes provided limited authority for the collection of biological samples, but subsequent legislation significantly broadened these powers. The Criminal Justice and Public Order Act introduced provisions allowing the police to collect DNA samples without consent in certain circumstances, particularly in cases involving serious offences. This marked a significant shift toward a more proactive approach to crime prevention and investigation.

The establishment of the National DNA Database represents one of the most significant achievements of the UK's forensic system. This database, which contains millions of DNA profiles, has become a critical tool for law enforcement agencies in identifying suspects and solving crimes. The centralized nature of the database allows for efficient comparison of DNA profiles, enabling the rapid identification of matches across different cases. The success of the National DNA Database in solving crimes has been widely acknowledged, and it is often cited as a model for other jurisdictions.

However, the extensive use of DNA databases in the United Kingdom has also raised important legal and ethical concerns. One of the most contentious issues has been the retention of DNA profiles from individuals who have been arrested but not convicted of any offence. Critics argue that such practices undermine the presumption of innocence and constitute an unjustified intrusion into personal privacy. The tension between public safety and individual rights has been a central theme in debates surrounding DNA profiling in the UK.

The role of human rights law in shaping the UK's approach to DNA profiling cannot be overstated. The European Convention on Human Rights, which has been incorporated into domestic law through the Human Rights Act, provides a framework for evaluating the legality of DNA-related practices. The right to privacy, as protected under Article 8 of the Convention, has been particularly relevant in this context. The landmark decision in *S and Marper v. United Kingdom* by the European Court of Human Rights highlighted the need for proportionality in the retention of DNA data. The Court held that the indefinite retention of DNA profiles of individuals who were not convicted of any crime constituted a violation of their right to privacy. This judgment prompted significant reforms in the UK's DNA retention policies, emphasizing the importance of balancing state interests with individual rights.

In addition to privacy concerns, the UK legal system has also addressed issues related to data protection and the security of genetic information. The Data Protection framework imposes obligations on authorities to ensure that DNA data is collected, stored, and used in a manner that respects individual rights. These safeguards are intended to prevent misuse and unauthorized access to genetic information, thereby enhancing public confidence in the system.

Another notable aspect of the UK's approach to DNA profiling is the emphasis on administrative efficiency. The centralized management of the National DNA Database allows for streamlined operations and coordination among law enforcement agencies. This has contributed to the rapid resolution of cases and has improved the overall effectiveness of the criminal justice system. However, the reliance on administrative mechanisms also raises questions about accountability and oversight, particularly in relation to the use and retention of DNA data.

The UK experience demonstrates the advantages of a well-regulated and institutionalized approach to DNA profiling. The combination of legislative clarity, centralized databases, and human rights safeguards has enabled the effective use of DNA technology while addressing ethical and legal concerns. Nevertheless, the ongoing debates surrounding privacy and data retention indicate that the system must continually adapt to evolving societal expectations and technological advancements.

6. DNA Profiling in India

The development and application of DNA profiling in India present a complex picture marked by scientific advancement on one hand and legal inadequacy on the other. While Indian courts and investigative agencies have increasingly relied on DNA evidence in criminal proceedings, the absence of a comprehensive statutory framework continues to create uncertainty and inconsistency in its application. Unlike jurisdictions such as the United States and the United Kingdom, where detailed legislative and institutional mechanisms govern the use of DNA technology, India largely depends on general evidentiary provisions and judicial discretion.

At present, the admissibility of DNA evidence in India is primarily governed by the provisions of the Indian Evidence Act, which recognize expert opinion as relevant evidence. DNA analysis is treated as a form of expert evidence, and courts rely on forensic reports submitted by laboratories. However, the Act does not specifically address the unique characteristics of DNA evidence, such as its statistical nature, methods of collection, or standards of reliability. This lack of specificity has led to variations in judicial interpretation and has limited the effective utilization of DNA technology in criminal investigations.

The procedural aspects of DNA collection are loosely governed by provisions under the criminal procedure framework, which allow medical examination of accused persons under certain conditions. However, the scope and limits of such powers remain unclear, particularly in cases involving non-consensual DNA testing. The absence of standardized procedures for collection, storage, and analysis further exacerbates the problem, increasing the risk of contamination and evidentiary challenges.

Despite these limitations, Indian courts have increasingly recognized the probative value of DNA evidence, especially in cases involving serious offences such as rape, murder, and terrorism. The judiciary has often relied on DNA profiling to corroborate other forms of evidence, thereby strengthening the prosecution's case. However, courts have also emphasized that DNA evidence must be evaluated cautiously and in conjunction with other evidence, rather than being treated as conclusive proof in isolation.

7. Constitutional Framework and Challenges

The use of DNA profiling in India raises significant constitutional questions, particularly in relation to the fundamental rights guaranteed under the Constitution. Two provisions are of central importance in this context:

the protection against self-incrimination and the right to privacy. The interplay between these rights and the investigative needs of the state creates a complex legal landscape that requires careful balancing.

The protection against self-incrimination ensures that an individual cannot be compelled to provide evidence against themselves. The key issue in the context of DNA profiling is whether the extraction of biological samples constitutes testimonial compulsion. Indian jurisprudence has generally distinguished between testimonial evidence and physical evidence, with the latter being considered outside the scope of this protection. However, the application of this distinction to DNA profiling remains contentious, particularly when the collection of samples is conducted without consent.

The right to privacy, recognized as a fundamental right under constitutional jurisprudence, has significant implications for the use of DNA technology. DNA contains highly sensitive personal information that extends beyond mere identification, including details about an individual's genetic traits and familial relationships. The collection and storage of such information by state authorities raise concerns about potential misuse and unauthorized access.

Any intrusion into the right to privacy must satisfy the tests of legality, necessity, and proportionality. In the context of DNA profiling, this requires that the collection of DNA samples be authorized by law, serve a legitimate state interest, and be proportionate to the objective sought to be achieved. The absence of a comprehensive legislative framework in India makes it difficult to ensure compliance with these requirements, thereby increasing the risk of constitutional violations.

Another constitutional concern relates to the presumption of innocence, which is a fundamental principle of criminal law. The collection of DNA samples from individuals who have not been convicted of any offence raises questions about the extent to which the state can intrude upon personal liberty in the name of investigation. Without clear guidelines, such practices may lead to an erosion of this principle and undermine the fairness of the criminal justice system.

8. Judicial Approach and Case Law Analysis

The Indian judiciary has played a crucial role in shaping the legal framework governing DNA profiling, often stepping in to fill the gaps left by the absence of legislation. Through various decisions, courts have attempted to balance the need for effective investigation with the protection of individual rights.

In the case of **Gautam Kundu v. State of West Bengal**, the Supreme Court addressed the issue of compulsory DNA testing in the context of a paternity dispute. The Court held that no individual can be compelled to undergo a DNA test without strong justification, emphasizing the importance of personal liberty and privacy. This decision established an important precedent by recognizing the intrusive nature of DNA testing and the need for judicial restraint.

Another significant case is **Selvi v. State of Karnataka**, which, although primarily concerned with techniques such as narco-analysis and brain mapping, laid down important principles regarding involuntary scientific methods. The Court held that the use of such techniques without consent violates the right against self-incrimination and the right to personal liberty. The reasoning in

this case has broader implications for DNA profiling, particularly in relation to non-consensual sample collection.

In contrast, the case of **Mukesh v. State (NCT of Delhi)** demonstrates the crucial role of DNA evidence in securing convictions. In this case, DNA profiling was used to establish the presence of the accused at the crime scene and to corroborate other evidence. The Court relied heavily on forensic findings, highlighting the importance of DNA evidence in modern criminal investigations.

These cases illustrate the evolving judicial approach to DNA profiling in India. While courts have recognized its evidentiary value, they have also emphasized the need to protect fundamental rights. The lack of clear legislative guidelines, however, continues to result in inconsistent decisions and uncertainty in the application of DNA technology.

9. Legislative Developments and the DNA Technology Regulation Bill

Recognizing the need for a comprehensive legal framework, the Indian government has proposed legislation aimed at regulating the use of DNA technology. The proposed law seeks to establish a structured system for the collection, storage, and analysis of DNA samples, as well as the creation of national and regional DNA databases. It also envisages the establishment of regulatory authorities to oversee the functioning of forensic laboratories and ensure compliance with prescribed standards.

While the proposed legislation represents a significant step forward, it has been subject to considerable criticism. Concerns have been raised regarding the broad powers of data collection, the potential for misuse of genetic information, and the lack of adequate safeguards for privacy. Critics argue that the bill does not sufficiently address issues such as consent, data retention, and access to DNA databases. There are also fears that the creation of large-scale DNA databases could lead to increased surveillance and profiling of individuals, particularly marginalized communities.

Another major concern is the absence of a robust data protection framework. In the absence of comprehensive privacy legislation, the storage and use of DNA data may expose individuals to risks of data breaches and unauthorized access. The lack of clear accountability mechanisms further exacerbates these concerns, raising questions about the effectiveness of the proposed regulatory system.

Despite these challenges, the need for a dedicated DNA law in India cannot be overstated. The current reliance on fragmented legal provisions and judicial interpretation is insufficient to address the complexities of DNA profiling. A comprehensive legislative framework is essential to ensure the effective and ethical use of DNA technology in criminal investigations.

10. Evidentiary and Practical Challenges in India

In addition to legal and constitutional issues, the use of DNA profiling in India faces several practical challenges that affect its reliability and effectiveness. One of the most significant issues is the lack of adequate forensic infrastructure. The number of accredited forensic laboratories in India is limited, leading to delays in the processing of DNA samples. These delays can have serious implications for the administration of justice, particularly in cases where timely evidence is crucial.

Another challenge is the lack of standardized procedures for the collection and handling of DNA samples. In many cases, improper collection or storage can lead to contamination, thereby compromising the integrity of the evidence. The absence of uniform guidelines also results in variations in laboratory practices, further affecting the reliability of DNA analysis.

The issue of chain of custody is another critical concern. For DNA evidence to be admissible in court, it must be demonstrated that the sample has been handled properly at every stage, from collection to analysis. Any break in this chain can lead to doubts about the authenticity of the evidence and may result in its rejection by the court.

Furthermore, there is a lack of specialized training among law enforcement officials and judicial officers in dealing with DNA evidence. This often leads to misinterpretation of forensic reports

and over-reliance on expert testimony without adequate scrutiny. The absence of clear guidelines for the evaluation of DNA evidence further complicates the situation.

11. Ethical Dimensions of DNA Profiling

The increasing reliance on DNA profiling in criminal investigations has raised profound ethical concerns that extend beyond legal and constitutional considerations. While DNA technology offers significant advantages in terms of accuracy and efficiency, it also poses serious questions regarding the ethical limits of state power, individual autonomy, and the protection of sensitive personal information. The ethical dimension of DNA profiling is particularly complex because genetic information is inherently personal and reveals far more than mere identity. It can provide insights into an individual's biological traits, health conditions, and familial relationships, thereby making it fundamentally different from other forms of identification such as fingerprints.

One of the central ethical concerns relates to the issue of consent. In many cases, DNA samples are collected without the explicit consent of individuals, particularly in criminal investigations involving serious offences. While such practices may be justified on the grounds of public safety and the need for effective law enforcement, they raise important questions about individual autonomy and bodily integrity. The absence of clear guidelines regarding consent further complicates the issue, especially in jurisdictions like India where legislative frameworks are still evolving. The ethical dilemma lies in determining the extent to which the state can override individual consent in the interest of justice.

Another significant ethical issue concerns the retention and use of DNA data. The creation of large-scale DNA databases has become a common practice in many countries, with the aim of enhancing investigative capabilities. However, the retention of DNA profiles, particularly those of individuals who have not been convicted of any offence, raises serious concerns about fairness and proportionality. The indefinite storage of such data may lead to stigmatization and may undermine the presumption of innocence. Moreover, the potential for misuse of DNA data by state authorities or private entities cannot be ignored. Unauthorized access, data breaches,

and discriminatory use of genetic information are real risks that must be addressed through robust safeguards.

The ethical implications of familial DNA searching further complicate the debate. This technique involves identifying potential suspects by analyzing the DNA profiles of their relatives. While it has proven effective in solving certain cases, it raises questions about the rights of individuals who are indirectly subjected to investigation without their knowledge or consent. The use of such techniques blurs the boundaries between individual and collective responsibility, raising concerns about privacy and fairness.

In addition to these issues, the possibility of genetic discrimination presents another ethical challenge. DNA information could potentially be used to discriminate against individuals in areas such as employment, insurance, and social services. Without adequate legal protections, individuals may be vulnerable to exploitation based on their genetic characteristics. This underscores the need for comprehensive legal frameworks that not only regulate the use of DNA profiling in criminal investigations but also protect individuals from broader societal risks.

12. Privacy, Surveillance, and Data Protection

The relationship between DNA profiling and the right to privacy is one of the most critical aspects of contemporary legal discourse. Privacy, as a fundamental right, encompasses the protection of personal information and the autonomy of individuals in controlling their own data. DNA profiling, by its very nature, involves the collection and analysis of deeply personal information, thereby posing a direct challenge to this right.

The creation of DNA databases has significantly enhanced the capabilities of law enforcement agencies, enabling them to identify suspects with remarkable efficiency. However, these databases also raise concerns about the emergence of a surveillance state, where individuals are constantly monitored and their personal information is stored indefinitely. The risk of such surveillance is particularly pronounced in the absence of strict legal safeguards and oversight mechanisms.

Data protection is a crucial component of privacy in the context of DNA profiling. The storage and management of genetic information require robust security measures to prevent unauthorized access and misuse. In jurisdictions such as the United Kingdom, data protection laws provide a framework for regulating the use of personal information, including DNA data. These laws impose obligations on authorities to ensure that data is collected and used in a lawful and transparent manner.

In contrast, the lack of a comprehensive data protection regime in India poses significant challenges. The absence of clear guidelines on data retention, access, and deletion increases the risk of misuse and undermines public confidence in the system. The implementation of DNA databases without adequate safeguards may lead to violations of privacy and could potentially be challenged on constitutional grounds.

The concept of proportionality plays a crucial role in addressing privacy concerns. Any interference with the right to privacy must be justified by a legitimate state interest and must be proportionate to the objective sought to be achieved. In the context of DNA profiling, this requires a careful assessment of the necessity and scope of data collection. The indiscriminate collection and retention of DNA samples are unlikely to meet this standard and may result in legal challenges

13. Comparative Evaluation of Legal Frameworks

A comparative analysis of the legal frameworks governing DNA profiling in the United States, the United Kingdom, and India reveals significant differences in their approaches to regulation and implementation. These differences reflect varying legal philosophies, institutional capacities, and societal priorities.

The United States adopts a judicially driven model that emphasizes the role of courts in determining the admissibility of scientific evidence. The development of standards such as the Daubert framework has enabled judges to evaluate the reliability of DNA evidence, thereby ensuring that only scientifically valid information is presented in court. The existence of a

well-established institutional framework, including the Combined DNA Index System, further enhances the effectiveness of DNA profiling in the United States. However, the expansion of DNA databases and the inclusion of profiles from arrestees have raised concerns about privacy and the potential for overreach.

The United Kingdom, on the other hand, follows a statutory approach characterized by detailed legislation and centralized database management. The National DNA Database serves as a key component of the UK's forensic system, enabling efficient identification and investigation. The integration of human rights principles into domestic law ensures that the use of DNA profiling is subject to judicial scrutiny and proportionality requirements. The reforms introduced following the decision in *S and Marper v. United Kingdom* demonstrate the UK's commitment to balancing public safety with individual rights.

India presents a contrasting picture, with a fragmented legal framework and limited institutional infrastructure. The absence of comprehensive legislation has resulted in reliance on general evidentiary provisions and judicial discretion. While courts have recognized the importance of DNA evidence, the lack of standardized procedures and regulatory mechanisms has limited its effectiveness. The proposed DNA legislation offers a potential solution, but its success will depend on the incorporation of robust safeguards and accountability measures.

14. Critical Analysis

The increasing reliance on DNA profiling in criminal investigations reflects a broader trend toward the identification of the legal system. While this development has undoubtedly enhanced the accuracy and efficiency of criminal justice, it also raises important questions about the role of science in law. The assumption that scientific evidence is inherently objective and infallible must be approached with caution, as errors in collection, analysis, and interpretation can lead to serious consequences.

One of the key challenges in the use of DNA evidence is the risk of over-reliance. Courts may be inclined to treat DNA evidence as conclusive, thereby overlooking other aspects of the case.

This can result in a narrow focus on scientific evidence at the expense of a holistic evaluation of facts. It is essential to recognize that DNA profiling, like any other form of evidence, is subject to limitations and must be assessed in conjunction with other evidence.

Another critical issue is the lack of uniformity in legal frameworks across jurisdictions. While developed countries have established comprehensive systems for regulating DNA profiling, developing countries such as India continue to face challenges in implementation. The absence of standardized procedures and institutional mechanisms undermines the reliability of DNA evidence and limits its potential benefits.

The ethical and constitutional concerns associated with DNA profiling further complicate the issue. The tension between individual rights and state interests requires a delicate balance that can only be achieved through well-designed legal frameworks. The experiences of the United States and the United Kingdom provide valuable lessons in this regard, highlighting the importance of judicial oversight, legislative clarity, and data protection.

15. Conclusion

DNA profiling represents one of the most significant advancements in forensic science and has fundamentally transformed the nature of criminal investigation. Its ability to provide accurate and reliable identification has strengthened the pursuit of justice and enhanced the credibility of legal systems. However, the effectiveness of DNA technology depends not only on its scientific accuracy but also on the legal and ethical frameworks that govern its use.

The comparative analysis of the United States, the United Kingdom, and India demonstrates that a robust legal framework is essential for the effective utilization of DNA profiling. While developed jurisdictions have successfully integrated DNA technology into their criminal justice systems, India continues to face significant challenges due to the absence of comprehensive legislation and institutional infrastructure.

The adoption of a balanced approach that integrates scientific advancement with constitutional safeguards is essential for the future of DNA profiling in India. This requires the enactment of

comprehensive legislation, the establishment of regulatory authorities, and the implementation of strong data protection measures. It also necessitates greater awareness and training among legal professionals to ensure the proper interpretation and use of DNA evidence.

Ultimately, the goal of the criminal justice system is to achieve justice while respecting the rights of individuals. DNA profiling, when used responsibly and ethically, has the potential to contribute significantly to this objective. However, without proper regulation and oversight, it may also pose serious risks to privacy and personal liberty. The challenge lies in harnessing the benefits of DNA technology while minimizing its potential harms, thereby ensuring that it serves as a tool for justice rather than a source of injustice.

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