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ROLE OF DNA PROFILING IN FORENSIC SCIENCE UNDER THE CRIMINAL JUSTICE SYSTEM

Appoorvaa S¹

I. ABSTRACT

DNA profiling is one of the most significant developments that have transformed the area of forensic science, providing a highly reliable method of identification of humans. DNA profiling in criminal investigation is greatly helping various law enforcement agencies to identify criminals, whether guilty or innocent. In India, DNA evidence is increasingly being used in serious criminal cases such as murder, sexual assault, and paternity, indicating that DNA profiling is gaining importance as evidence in the criminal justice system. This article aims to critically examine the importance of DNA profiling in forensic science and law, specifically with regard to its evidentiary value under the Indian legal system. Furthermore, this article attempts to examine the scientific basis of DNA profiling and its admissibility as evidence under various provisions of law such as the Bharatiya Sakshiyā Adhīniyam, 2023 and Bharatiya Nāgarik Surakṣa Sanhita, 2023. The paper further delves into important judicial pronouncements such as Nandlal Wasudeo Badwaik v. Lata Nandlal Badwaik and Krishan Kumar Malik v. State of Haryana, which have also helped in building the legal framework surrounding DNA evidence in India. Furthermore, this article addresses the legislative vacuum left by the withdrawal of the DNA Regulatory Bill and the privacy risks posed by the Criminal Procedure (Identification) Act, 2022. Although DNA profiling is the most accurate method for identification, the increasing trend of using this technology also gives rise to serious legal and ethical issues in relation to privacy, consent, and the possible misuse of genetic information. The lack of an effective legal framework in this regard makes it even more complex. The article concludes that even though DNA Profiling is an essential element in the

¹ LL.M (Criminal Law and Criminal Justice Administration), 4th Semester, Student at School of Excellence in Law, The Tamil Nadu Dr. Ambedkar Law University, Chennai (India).
Email:appoorvaasundartana@gmail.com

current criminal investigation system, its use must be regulated in such a manner that a proper balance is achieved in effective law enforcement and the protection of fundamental human rights.

II. KEYWORDS

DNA Profiling, Criminal Investigation, Evidentiary value, Forensic science.

III. INTRODUCTION

The growing complexities of crimes in modern society have called for the use of advanced and accurate techniques of investigation. Conventional forms of evidence, such as the use of eyewitness accounts and confessions, have faced considerable criticism for their inaccuracy, bias, and potential for manipulation. In this regard, the role of forensic science as an integral part of the criminal justice process has become indispensable, with the use of objective and scientifically authentic means of proof.

In this context, DNA profiling has emerged as a major advancement in forensic science. Through the analysis of the genetic composition of individuals, DNA profiling is able to accurately identify an individual and establish a strong link between the evidence and the individuals involved in the commission of a crime. This has enabled DNA profiling to become an integral part of the investigation of major crimes, not only leading to the conviction of criminals but also protecting the interests of innocent individuals.

With the Indian legal system witnessing a major shift from colonial legislative enactments to contemporary enactments like the Bharatiya Sakshya Adhiniyam, 2023², and the Bharatiya Nagarik Suraksha Sanhita, 2023³, the Indian legal system is witnessing the emergence of a new chapter in the admissibility of DNA evidence. While the Indian legal system recognizes the admissibility of expert opinion⁴ through the provisions of Section 39 of the Bharatiya Sakshya Adhiniyam, the Indian legal system has expanded the powers

² The Bharatiya Sakshya Adhiniyam, 2023 (Act 47 of 2023).

³ The Bharatiya Nagarik Suraksha Sanhita, 2023 (Act 46 of 2023).

⁴ Ibid., s. 39.

of the authorities⁵ through the provisions of Section 51 of the Bharatiya Nagarik Suraksha Sanhita. However, this is without the emergence of a specific legislative enactment regulating DNA technology.

The withdrawal of the DNA Technology (Use and Application) Regulation Bill, 2019, in 2023 has resulted in a legislative vacuum, and India is left without a centralized DNA database or a regulatory authority⁶. This is a major concern with regard to the security of genetic data, chain of custody, and the misuse of personal information. What is more interesting is that it brings into focus the constitutional implications of DNA profiling, especially with regard to the right to privacy under Article 21 of the Indian Constitution. Although the Indian courts have accepted DNA evidence for its scientific reliability, the legal framework for the use of DNA evidence is wanting. The lack of a clear legal framework with regard to the use of DNA evidence requires a critical look at the use of DNA evidence in India.

A. Research Objectives

1. To examine the role and significance of DNA profiling in the field of forensic science and the criminal justice system.
2. To analyze the evidentiary value and admissibility of DNA evidence under the Bharatiya Sakshya Adhinyam, 2023 and the Bharatiya Nagarik Suraksha Sanhita, 2023.
3. To study the judicial approach towards DNA profiling through important judicial pronouncements in India.
4. To evaluate the constitutional, ethical, and privacy concerns associated with the use of DNA profiling technology.
5. To propose a balanced legal framework ensuring effective criminal investigation while safeguarding fundamental rights.

⁵ *Ibid.*, s. 51.

⁶ The DNA Technology (Use and Application) Regulation Bill, 2019 (Bill No. 162 of 2019).

B. Research Questions

1. What is the significance of DNA profiling in forensic science and criminal investigation?
2. To what extent is DNA evidence admissible and reliable under the Indian legal framework?
3. How have Indian courts interpreted and applied DNA evidence in criminal and civil proceedings?
4. What are the legal and ethical concerns arising from the increasing use of DNA profiling in India?
5. Whether the existing legal framework sufficiently regulates the collection, storage, and use of DNA data in India?

C. Research Methodology

The present study adopts a doctrinal and analytical method of research. The research is primarily based on secondary sources, including statutes, judicial decisions, Law Commission Reports, books, journal articles, and authoritative online resources relating to forensic science and DNA profiling. The study further undertakes an analytical examination of the Bharatiya Sakshya Adhiniyam, 2023, the Bharatiya Nagarik Suraksha Sanhita, 2023, and the Criminal Procedure (Identification) Act, 2022, with reference to the admissibility and evidentiary value of DNA evidence. Relevant judicial pronouncements and comparative scholarly materials have also been examined to evaluate the legal and constitutional implications associated with DNA profiling in India.

IV. INTERSECTION OF FORENSIC SCIENCE AND LAW IN DNA PROFILING

Forensic science is defined as the application of scientific knowledge and techniques with the objective of investigation and adjudication of legal issues⁷. It is a bridge that connects

⁷ B.R. Sharma, *Forensic Science in Criminal Investigation and Trials* (LexisNexis, 2016).

two different fields, namely, science and law. The application of forensic science is essential in arriving at a judgment with greater accuracy. The main advantage is that it is not based on human perception or remembrance, as is the case with other evidence. Unlike other evidence, forensic science is based on scientific investigation that increases the credibility of the criminal justice system.

The application of forensic science in the legal arena is associated with “expert evidence.” The courts rely on experts to present scientific evidence in a form that is easily comprehensible within the courtroom. In India, such evidence is analyzed under the guidelines provided by the legal statutes on expert opinion⁸, which allows the courts to make a judgment on the issue.

Among the different branches of forensic science, DNA profiling holds a prominent position in the field of human identification with a high degree of accuracy. It is based on the analysis of genetic material derived from biological evidence, which helps in distinguishing individuals with a high degree of accuracy. This has made DNA profiling an important tool in cases where human identification is critical, such as in the investigation of violent crimes, sexual offenses, and cases involving unknown perpetrators.

From a legal point of view, DNA profiling has provided a significant boost to the evidentiary process with the introduction of scientifically verifiable evidence. It allows a direct comparison between the biological evidence collected at the crime scene and the evidence collected from individuals, thereby linking them directly or ruling them out. However, it is important that proper procedural guidelines are followed in the use of DNA profiling evidence in the courtroom.

V. MEANING AND DEFINITION OF DNA PROFILING

DNA profiling is the identification of individuals using the unique characteristics of the human genome. It is done by examining the unique features of the DNA sequence that

⁸ The Bharatiya Sakshya Adhinyam, 2023 (Act 47 of 2023), s. 39.

are different from one person to another. It is different from other forms of identification because DNA profiling is based on evidence from the biological system of the human body.

In the legal system, DNA profiling is used to identify individuals, connect suspects with crimes, and settle disputes over parentage⁹. This is due to the increased reliance on the criminal justice system as evidence.

B.R. Sharma defines it as “a is a process by which the unique profile of the DNA of a person is determined”.¹⁰

Sir Alec Jeffreys, the pioneer of this technique, developed the concept of DNA fingerprinting through the identification of highly variable regions within human DNA that could be used to distinguish individuals from biological samples, except in the case of identical twins.¹¹

VI. STRUCTURE OF DNA

DNA stands for Deoxyribonucleic Acid, which is the hereditary substance found in nearly every cell of the human body.¹²

The DNA molecule resembles a ladder with two sides; each made of sugar-phosphate backbones.

The rungs of the ladder are made of two pairs of bases: one pair consisting of Adenine and Thymine, and the other pair consisting of Guanine and Cytosine.

These are known as base pairs, and each pair forms one rung of the ladder with each base extending from each of the two sides and meeting at the center.

⁹ The Criminal Procedure (Identification) Act, 2022 (Act 11 of 2022).

¹⁰ Supra note 8.

¹¹ A.J. Jeffreys, V. Wilson et al., ‘Individual-specific “fingerprints” of human DNA’ (1985) 316 Nature 76–79.

¹² See National Human Genome Research Institute, ‘Deoxyribonucleic Acid (DNA)’, available at: <https://www.genome.gov/genetics-glossary/Deoxyribonucleic-Acid> (last visited on 10 March, 2026).

But the most significant feature of the DNA molecule is that the two pairs of bases follow the pairing rule strictly.

Adenine always pairs with thymine, while cytosine always pairs with guanine. The twisted ladder is known as a DNA helix, with each complete twist being made up of ten base pairs. There are billions of base pairs in a single DNA molecule, creating a complex genetic code.

The sequence and arrangement of these pairs define various characteristics in humans, such as physical attributes, biological functions, and, in some instances, diseases.¹³ These pairs are grouped into specific regions, known as alleles or mini satellites, which contain repeated DNA sequences. These regions are unique in every person, thus being of great significance in the field of DNA profiling.

The structure of the DNA, particularly the variation in the repeated sequences, varies in every person, thus making every human being unique. More than 99.9% of the human DNA structure is the same in every person, and it is the 0.1% variation in the structure that defines the identity of every person. However, in the case of monozygotic or identical twins, the structure of the DNA is the same since they are derived from the same fertilized egg.

VII. TYPES OF DNA USED IN FORENSIC ANALYSIS

In the forensic science field, the selection of DNA used for examination largely depends on the nature, condition, and quality of the biological matter collected from the crime scene. In general, two major types of DNA are used for forensic examinations. These are nuclear DNA and mitochondrial DNA.

¹³ J.D. Watson and F.H.C. Crick, 'Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid' (1953) 171 *Nature* 737, available at: <https://doi.org/10.1038/171737a0> (last visited on 10 March 2026).

A. Nuclear DNA (nDNA)

Nuclear DNA, as the name indicates, is found inside the nucleus of the cell. It is equally inherited from both biological parents, with each contributing approximately 50 percent of the total genetic makeup of an individual. Nuclear DNA exhibits a high level of polymorphism, or genetic variation, thus providing a detailed individual identification profile.

In the forensic science field, nuclear DNA is regarded as the “gold standard” as it helps in the creation of a unique genetic profile to distinguish one individual from another with a very high level of certainty, apart from the possibility of occurrence of identical twins¹⁴. It is the most commonly used type of DNA in criminal trials to prove the involvement of suspects in crimes by matching them with biological matter such as blood, saliva, semen, and tissue samples

B. Mitochondrial DNA (mtDNA)

DNA found outside the nucleus, in structures known as mitochondria, is known as mitochondrial DNA. Unlike nuclear DNA, mitochondrial DNA is passed on solely along the maternal line, implying that individuals with the same maternal lineage possess the same type of mitochondrial DNA.

Although mitochondrial DNA does not possess the uniqueness characteristic of nuclear DNA, it has been widely used in forensic science because of its durability. It is highly resistant to degradation and can be retrieved in instances where nuclear DNA is either lacking or has been degraded. It is thus used in the investigation of charred human remains, old skeletal remains, or hair shafts without roots.

VIII. HISTORY OF DNA AND DNA PROFILING

The history of DNA can be dated back to the nineteenth century when the Swiss scientist Friedrich Miescher discovered the presence of a substance in the nuclei of white blood

¹⁴ B.S. Nabar, *Forensic Science in Crime Investigation* 89 (Asia Law House, Hyderabad, 3rd edn., 2007).

cells in the year 1869 and referred to the substance as “nuclein.” Even though this was the initial identification of the substance that would later be known as DNA, its importance was not understood until much later in the century as scientists believed that proteins played the key role in the passing of hereditary information.¹⁵

A major breakthrough in the history of DNA was made by Oswald Avery and colleagues in the mid-twentieth century when they demonstrated in the year 1944 that DNA is the key molecule involved in the passing of hereditary information. This breakthrough was instrumental in changing the way the scientific community viewed the role of DNA.

The structure of the molecule was also discovered by James Watson and Francis Crick in the year 1953 when they developed the double helix model of the molecule with the help of the work done by Rosalind Franklin using X-ray diffraction.

Further advances in the study of DNA were achieved through the creation of specialized laboratory techniques in the 1970s and 1980s. One of the most important discoveries in this era was the invention of the Polymerase Chain Reaction (PCR), which allows scientists to amplify small pieces of DNA for detailed examination.¹⁶ This technique significantly improved the potential of DNA examination in criminal cases, especially when small pieces of evidence were involved.

The idea of DNA profiling was first proposed by Sir Alec Jeffreys in 1984 when he discovered that some parts of the DNA molecule contain repeating patterns of sequences unique to each individual. This important discovery enabled scientists to create unique

¹⁵ Evelyn Lamm, Oren Harman and Stephan J. Veigl, “Before Watson and Crick in 1953 Came Friedrich Miescher in 1869”, *Genetics*, Vol. 215, No. 2, 2020, pp. 291–296, available at: <https://doi.org/10.1534/genetics.120.303195> (last visited on 17 March 2026).

¹⁶ Kary B. Mullis, “The Unusual Origin of the Polymerase Chain Reaction”, *Scientific American*, Vol. 262, No. 4, 1990, pp. 56–61, available at: <https://doi.org/10.1038/scientificamerican0490-56> (last visited on 17 March 2026).

profiles of individual DNA, leading to the creation of DNA fingerprinting as a legitimate technique of identification¹⁷.

Since then, DNA profiling techniques have gained wide acceptance across the globe as an essential tool in forensic science. Techniques such as Short Tandem Repeat (STR) analysis and automated DNA sequencing have increased the accuracy and reliability of DNA tests. DNA profiling techniques have slowly but surely entered the criminal justice system in India, with the courts increasingly admitting the evidence of DNA profiling, though the regulations regarding the same are still evolving.

IX. CORE STEPS IN DNA PROFILING

The process of DNA profiling is the series of scientific steps involved in the analysis of the sample to obtain a reliable DNA profile. All the steps involved in DNA profiling must be carefully taken to obtain accurate and reliable results.

A. DNA Extraction

DNA extraction is the first step in the process of DNA profiling, which involves the extraction of the genetic material from biological evidence-like blood, saliva, semen, hair roots, bones, and tissues, etc. The success of the entire forensic analysis depends on the quality of the extracted DNA at this step.

The process of DNA extraction starts with the lysis of the cells, in which the cell membrane and the nuclear membrane are ruptured by the use of chemical reagents or enzymes, releasing the DNA along with other cellular components, including proteins, lipids, and RNA. The unwanted cellular components are removed by the process of purification, producing clean DNA.¹⁸

¹⁷ Alec J. Jeffreys, V. Wilson and S.L. Thein, "Individual-specific 'fingerprints' of human DNA", *Nature*, Vol. 316, No. 6023, 1985, pp. 76-79, available at: <https://doi.org/10.1038/316076a0> (last visited on 17 March 2026).

¹⁸ J.L. Bukyya, M.L.A. Tejasvi, A. Avinash et al., 'DNA Profiling in Forensic Science: A Review' (2021) 8(4) *Global Medical Genetics* 135, available at: <https://doi.org/10.1055/s-0041-1728689> (last visited on 17 March 2026).

The condition of the biological sample plays an important role in the extraction process. Samples exposed to environmental elements such as heat, moisture, and microorganisms may affect the integrity of the DNA. This may cause difficulties during the extraction process.

Various techniques of DNA extraction are employed by forensic labs based on the nature of the sample received:

- 1. Organic Extraction (Phenol-Chloroform Method):** This DNA extraction involves chemicals such as phenol and chloroform. These chemicals separate the DNA from proteins when added to the solution. The chemicals form two distinct layers when mixed with the solution, with the top layer comprising pure DNA and the bottom layer comprising impurities. This technique of DNA extraction takes a long time to process and involves hazardous chemicals.
- 2. Chelex Extraction Method:** In this technique of DNA extraction, chemicals such as Chelex are added to the solution to bind metal ions, which may harm the DNA. The solution is then heated to separate the cells and allow the DNA to mix with the solution. This technique of DNA extraction takes less time to process and is cost-effective, although the purity of the extracted DNA may not be high.¹⁹
- 3. Silica-Based Extraction Method:** This method makes use of columns of silica, which binds the extracted DNA under certain chemical conditions. Impurities are removed, and the extracted DNA is collected using a buffer solution. This method is commonly used in modern, automated labs due to its efficiency, precision, and ability to handle multiple samples.
- 4. Differential Extraction Method:** This method is specifically used in cases where there is a mixture of cells. This is usually used in sexual offence cases. In this method, epithelial cells (from the victim) and sperm cells (from the

¹⁹ P.S. Walsh, D.A. Metzger and R. Higuchi, 'Chelex 100 as a Medium for Simple Extraction of DNA for PCR-Based Typing from Forensic Material' (1991) 10(4) Biotechniques 506.

accused) are separated using a differential extraction technique. In forensic science, it is essential to maintain proper procedures during the extraction process. This is because contamination of the DNA may cause incorrect conclusions. For example, even a small amount of foreign matter may affect the results. For this reason, forensic laboratories maintain proper environments and use sterilized equipment.²⁰ In law, improper extraction of DNA or contamination of the DNA may affect the integrity of the evidence. For this reason, it is essential to maintain scientific integrity during this process.

B. DNA Quantification

DNA quantification is the evaluation of the amount and quality of the extracted DNA. It is the essential step before the analysis of the DNA extracted from the crime scene. It is necessary to have the optimum amount of DNA before the analysis.²¹

In the forensic science field, the most widely used technique of DNA quantification is the quantitative Polymerase Chain Reaction (qPCR).

C. Quantification Methods

The techniques of DNA quantification can be classified as follows:

1. Non-Nucleic Acid-Based Methods: This category of DNA quantification includes techniques that are not directly related to the analysis of the DNA molecule but are related to the analysis of the biological substance:

- **Microscopic and Macroscopic Examination:** Analysis of evidence such as bloodstain evidence, hair evidence, etc.

²⁰ ScienceDirect, 'Differential Extraction' available at: <https://www.sciencedirect.com/topics/neuroscience/differential-extraction> (last visited on 10 May 2026).

²¹ Supra note 19.

- **Chemical and Immunological Methods:** Analysis of the evidence using chemical tests or antigen-antibody reaction. (e.g., presumptive tests for blood or semen).

These techniques are preliminary in nature but assist in determining whether DNA analysis is required or not.

D. DNA-Based Total Genomic Methods

These methods involve the quantification of DNA as follows:

1. **UV Spectrophotometry:** The concentration of DNA is determined using this method, but it cannot distinguish human DNA from contaminants.
2. **Fluorescence-Based Methods:** These include assays that utilize a dye to bind with DNA, thereby providing a more accurate analysis.
3. **Agarose Gel Electrophoresis:** This is helpful in determining both the quantity and quality of DNA since it can be visualized on a gel.

These techniques are applicable for measuring total DNA content but cannot be very specific in forensic analysis.

E. DNA-Based Target-Specific Methods

These are the most advanced and widely used techniques in the field of forensic science:

1. **Real-Time PCR (qPCR):** It measures the amount and quality of the DNA, as well as its degradation and the presence of inhibitors.
2. **Human Autosomal DNA Quantification:** It checks whether the DNA is of human origin.
3. **Y Chromosome DNA Analysis:** It is used in male-specific identification cases, especially in sexual assault cases.
4. **Mitochondrial DNA Analysis:** It is used in degraded DNA cases.
5. **Alu Repeat qPCR:** It specifically targets highly repetitive human DNA sequences to accurately quantify them.

- 6. Multiplex Real-Time PCR:** It can quantify multiple DNA targets in one reaction.

All these techniques are very sensitive and specific and are the preferred techniques in the field of forensic science.

F. Alternative and RNA-Based Methods

- 1. End Point PCR Quantification:** In this method, the quantification of the extracted DNA is done after the completion of the PCR cycle, which is not as accurate as the real-time PCR method.
- 2. RNA-Based Quantification:** In some cases, this method is used to find the type of tissue or the biological source of the extracted DNA.²²

Alternative and RNA-based methods are additional and are used in special cases of forensic analysis.

Quantification of DNA plays an essential role in the reliability of the analysis:

1. It checks whether the DNA is enough to conduct the analysis.
2. It helps in the optimization of the amount of DNA to be used in the analysis.
3. It detects degraded or contaminated DNA.
4. It detects mixtures of DNA.
5. It checks whether the DNA is overloaded or underloaded.
6. It checks the consistency of the analysis.

If the DNA is not quantified, the analysis may be incomplete or incorrect, which affects the reliability of the evidence.

From a forensic point of view, it ensures that only appropriate samples are subjected to amplification and tested, thus maintaining scientific accuracy.

²² I. Gaballah, 'DNA vs RNA in Forensic Applications: Regulations-Fallacies' (2020) 3(3) Journal of Criminology and Forensic Studies, available at: <https://academicstrive.com/JOCFS/JOCFS180048.pdf> (last visited on 18 March,2026).

From a legal perspective, it enhances the reliability and acceptability of DNA evidence, as it proves that the results are derived from enough and pure DNA. This implies that any inadequacy in the quantification step can be contested in court.

G. DNA Amplification

DNA amplification is the technique of creating an increased number of copies of a particular segment of the DNA. In forensic science, this is done by the Polymerase Chain Reaction (PCR) method. It is useful for the analysis of even the smallest DNA samples.

It is obvious that the quantity of the DNA sample collected from the crime scene is very low. In the Polymer Chain Reaction method, the particular segment of the DNA is replicated into millions of copies.

1. Methods of DNA Amplification

In the field of Forensic Science, various forms of PCR are employed depending upon the nature of the samples obtained:

- **Conventional PCR:** Basic form of PCR, where amplification of DNA is carried out
- **Real-Time PCR (qPCR):** Simultaneous amplification and quantification of DNA are possible
- **Multiplex PCR:** Simultaneous amplification of various segments of the DNA molecule is possible. This is the most common form of PCR in Forensic Science
- **Nested PCR:** This form of PCR is employed in cases where high sensitivity is required

Among these, multiplex PCR is the commonly employed form in forensic science, as it allows simultaneous investigation of various genetic markers

The amplification process is very sensitive and allows for the analysis of trace amounts of biological evidence, e.g., skin cells or small blood spots (“touch DNA”).

With regard to the legal implications, the DNA amplification process can be viewed as a link between DNA analysis and DNA extraction. In terms of the legal implications, the successful amplification process guarantees the availability of sufficient DNA material for analysis.

X. TECHNIQUES OF DNA PROFILING

A. Restriction Fragment Length Polymorphism (RFLP)

One of the first techniques of DNA profiling for the analysis of genetic variations among individuals is Restriction Fragment Length Polymorphism (RFLP). It is based on the principle of variations in the lengths of the DNA fragments when cut by particular enzymes.

1. Principle of RFLP: RFLP works on the principle that DNA has specific recognition sites where certain enzymes called restriction enzymes can act upon it. This leads to fragments of varying lengths depending upon the genetic composition of a person.²³ As the arrangement of these recognition sites varies in different people, it acts as a unique identifier.

2. Procedure of RFLP

The procedure of RFLP involves a series of steps:

- **DNA Isolation:** This involves the extraction of DNA from a sample.
- **Digestion:** This is done using enzymes that cut the DNA into fragments.
- **Gel Electrophoresis:** This separates the fragments based on their lengths.
- **Southern Blotting:** This involves the transfer of fragments to a membrane.
- **Hybridization:** This involves the attachment of a probe to a certain fragment.

²³ J.M. Butler and D.J. Reeder, 'Detection of DNA Polymorphisms Using PCR-RFLP and Capillary Electrophoresis' in K.R. Mitchelson and J. Cheng (eds.), *Capillary Electrophoresis of Nucleic Acids* (Humana Press 2001), available at: <https://experiments.springernature.com/articles/10.1385/1-59259-116-7:49> (last visited on 18 March, 2026).

- **Visualization:** This leads to a banding pattern that can be used to compare.

The banding pattern thus obtained can be used to compare the similarity or dissimilarity in DNA.

3. Forensic Applications

RFLP technology was extensively employed in the early days of forensic investigations for the following purposes:

- Identification of criminals in criminal cases
- Paternity tests
- Detection of genetic variations

RFLP technology marked the first milestone in the identification of criminals using the DNA fingerprinting technique. It has been extensively employed for the investigation of criminal cases.

4. **Advantages of RFLP:** RFLP technology provides highly reliable results. It is an accurate technique. The results are easily identifiable. RFLP technology is useful for the analysis of genetic variations.
5. **Limitations of RFLP:** RFLP technology requires large amounts of quality DNA. RFLP technology is not useful for degraded DNA. RFLP technology is time-consuming. RFLP technology is no longer being used. RFLP is of immense historical significance as it paved the way for modern DNA profiling techniques. Although it is no longer used in its original form, it has been replaced by more sophisticated techniques like STR analysis, it was this technique that paved the way for DNA evidence in courts.

B. Polymerase Chain Reaction (PCR)

The Polymerase Chain Reaction (PCR) is an important method used in modern DNA profiling for amplification of specific DNA sequences. This method allows forensic scientists to produce millions of copies of a specific DNA sequence present in a small

sample of DNA. The PCR method has greatly transformed the field of forensic science by allowing scientists to analyze DNA evidence that was previously too small for analysis.

1. Principle of PCR

The PCR method was developed based on the principle of DNA replication.

The process involves three stages:

- **Denaturation:** This is the first step in the cycle of PCR, in which the double helix of DNA is denatured by heat and separated into two strands of DNA. Temperature: 94-95°C (may rise up to 98°C for hard samples). Here the hydrogen bonds between base pairs of DNA are broken, and two strands of DNA are formed
- **Annealing:** At this step, the temperature is decreased in order for primers to bind to their complementary strands of DNA. Temperature: 50-65°C (usually 55-60°C). It enables primers to bind to specific strands of DNA. The temperature depends on the melting point of primers
- **Extension (Elongation):** At this step, DNA polymerase is used for creating new strands of DNA by adding nucleotides onto the primers. Temperature: 72°C. Optimal temperature for Taq DNA Polymerase. Complementary strands of DNA are formed in this stage ²⁴
- **Cycling and Final Extension:** The above three steps will be repeated 25-35 times, and this will result in exponential synthesis of DNA. Final Extension: 72°C for 5-10 minutes for completion of any strands of DNA that were not completed in the above steps. The reaction occurs in a thermal cycler, which controls the temperature changes necessary for each step of the reaction.

²⁴ National Human Genome Research Institute (NHGRI), 'Polymerase Chain Reaction (PCR) Fact Sheet' available at: <https://www.genome.gov/about-genomics/fact-sheets/Polymerase-Chain-Reaction-Fact-Sheet> (last visited on 10 May 2026).

DNA synthesis occurs because of the use of a DNA polymerase that resists degradation at high temperatures, such as Taq DNA polymerase.

The procedure is very specific because the primers are designed to bind to very specific areas of DNA.

2. Advantages of PCR

- Only a small amount of DNA is required
- Can be used in degraded DNA cases
- Can produce quick results
- Can be used to examine trace or touch DNA
- Forms the basis for more recent technologies such as STR

3. Limitations of PCR

- Highly sensitive to contamination
- Requires careful handling in a laboratory environment
- Errors in the process can impact results
- Can be difficult to interpret in mixed DNA cases

4. Forensic and Legal Relevance

PCR plays a vital role in contemporary forensic science and has greatly extended the range of biological evidence that can be considered in criminal investigations. This technique has made it possible to investigate cases that were previously considered unsolvable.

From a legal viewpoint, it can be argued that PCR-based evidence is readily accepted because it is a reliable technique. However, it should be noted that it is a sensitive technique that requires strict compliance with procedural requirements to avoid any impact on the admissibility of results.

C. Short Tandem Repeat (STR) analysis

Short Tandem Repeat (STR) analysis is the most commonly employed method in contemporary forensic DNA profiling for human identification. STR analysis involves

the examination of specific segments of DNA where short sequences of nucleotides consisting of 2-6 pairs of nucleotide bases are repeated in tandem. The number of repeated nucleotide pairs differs from one person to another.²⁵

1. Principle of STR Analysis

The principle on which STR analysis is based is the fact that there are certain areas in DNA where repeat patterns vary. While the majority of the human DNA sequence is the same, the STR areas vary in the number of repeats in a particular area or loci. If several STR loci are analyzed, a distinct DNA profile is created. In a typical case, 16 to 24 STR loci are investigated. This gives STR analysis extremely high discriminatory power. The chances of two different individuals having the same STR profile are extremely low, less than one in a billion.

2. STR Analysis Procedure

There are a series of laboratory techniques involved in generating a DNA profile during STR analysis procedure. They are as follows:

- **STR Amplification:** STRs are amplified by PCR and thus allow for the creation of millions of STR copies, starting from the smallest samples of DNA.
- **Capillary Electrophoresis:** Fragments of DNA molecules are sorted based on their sizes; the smaller ones move faster than the larger ones.
- **Fluorescence Detection:** The fluorescence dye that is bound to the DNA fragments emits signals and allows identifying different STR loci at once.
- **Electropherogram Generation:** These signals are transformed into a graph of DNA profile, known as electropherogram, with peaks standing for STR alleles and their abundance.

²⁵ S. Panneerchelvam and M.N. Norazmi, 'DNA Profiling in Human Identification: From Past to Present' (2023) 30(6) Malaysian Journal of Medical Sciences 5, available at: <https://doi.org/10.21315/mjms2023.30.6.2> (last visited on 21 March,2026).

- **DNA Comparison and Analysis:** Generated DNA profile is compared to reference samples for determining whether there is a match, exclusion, or no conclusion can be made; after that, random match probability is calculated.

3. Advantages of STR Analysis

- Highly precise and dependable
- Small amounts of DNA can be used
- Multiple regions can be tested simultaneously (multiplexing)
- Fast and efficient results
- Well-established in forensics and courtrooms

4. Limitations of STR Analysis

- Susceptible to contamination
- Complex interpretation for DNA mixtures
- Needs special equipment and knowledge

5. Forensic and Legal Significance

The STR method of DNA analysis is regarded as the benchmark in forensic genetics because of its accuracy and reliability. It is very important in criminal cases, paternity cases, identification of victims of disasters, and missing persons' cases.

Legally, the acceptance of STR-based DNA evidence in the courts is high, on condition that appropriate protocols are followed. The power of statistics associated with STR DNA profiling has increased the weight of DNA evidence in court.

XI. LAW COMMISSION REPORTS FOR DNA PROFILING

The Law Commission of India has significantly contributed to the development of the legal framework governing DNA profiling by examining its scientific utility alongside constitutional and ethical concerns

A. 185th Law Commission Report (2003) titled Review of the Indian Evidence Act, 1872

The Law Commission Report No. 185, headed by Justice M. Jagannadha Rao, conducted an extensive analysis of the Indian Evidence Act, 1872, focusing specifically on the evidentiary relevance of scientific advancements like DNA profiling. The recommendation for reform made in this report included an amendment to Section 112 of the Evidence Act (currently Section 116 of the Bharatiya Sakshya Adhiniyam, 2023).

A major flaw noted by the Commission in the law was the provision permitting proof of non-paternity only based on absence of access by spouses. Considering the development in medicine and forensic sciences, it was suggested that grounds for proving non-paternity should be widened to include other exceptions such as impotency proved scientifically, blood groups testing, and DNA Profiling.²⁶

The Commission, nevertheless, adopted a cautious approach regarding DNA evidence, recommending that DNA testing should be done strictly for negative purposes, i.e., as a means of disproving paternity, not establishing it. This meant that DNA testing was subject to proper judicial oversight because of the concern about the sanctity and dignity of children involved.

B. 271st Law Commission Report (2017) titled Human DNA Profiling – A Draft Bill for the Use and Regulation of DNA-Based Technology

The 271st Law Commission Report (2017), under the chairmanship of Justice B.S. Chauhan, represented a paradigm shift as it laid stress on the necessity of establishing a regulatory mechanism for DNA profiling. The Report, titled ‘Human DNA Profiling – A Draft Bill for the Use and Regulation of DNA-Based Technology,’ annexed a draft legislation titled the ‘DNA Based Technology (Use and Regulation) Bill, 2017,’ in response

²⁶ Law Commission of India, Review of the Indian Evidence Act, 1872, Report No. 185 (March 2003).

to the increasing application of DNA profiling without a comprehensive regulatory framework in the legal system.

The Commission acknowledged that DNA profiling had a two-way impact since it could be used effectively as an investigative technique while also posing threats to Article 21 rights, namely the right to privacy.²⁷

Some of the important safeguards suggested in the report included the formation of a DNA Regulatory Board to regulate laboratories and data banks, as well as the setting up of DNA databases at the national and regional levels. It was also stressed that principles such as the principle of purpose limitation, whereby the collection of DNA would be limited only for identification purposes in criminal matters and missing persons' cases and would not include any disclosure of sensitive or private information of the person.

Another important issue stressed in the report was the protection of DNA data, which included processes through which DNA samples of those acquitted or cleared of being suspects could be deleted from the database. Informed consent, excluding cases of grave offences, was another important point.

XII. LEGAL FRAMEWORK GOVERNING DNA PROFILING IN INDIA

The legal framework for DNA profiling in India is regulated via a series of legal instruments such as rules of evidence, process laws, data protection laws, constitutional provisions, and reform proposals. Nevertheless, due to the lack of an independent law governing DNA profiling in India, the existing system is incomplete, which gives rise to questions about coherence, responsibility, and individual rights.

A. The Constitution of India, 1950

Use of DNA profiling in India is significantly linked to constitutional law provisions especially those contained in Part III of the Indian Constitution. This involves a direct

²⁷ Law Commission of India, DNA Based Technology (Use and Regulation) Bill, 2017, Report No. 271 (July 2017).

relationship between the use of genetic material and certain fundamental rights including the right to privacy and the right to personal liberty among others.

The most notable event that is worth mentioning in this regard is the Supreme Court decision in the case of Justice K.S. Puttaswamy v. Union of India²⁸. According to this landmark decision by the Supreme Court of India, privacy is a fundamental right in accordance with Article 21 of the Indian Constitution. Since DNA profiling entails collecting and analysing someone's genetic information, then this act is clearly an invasion of both body and mind privacy. Consequently, such interventions will have to meet the constitutional criteria of legality, necessity, and proportionality.

Moreover, Article 20(3) safeguards citizens from being compelled to testify against themselves²⁹. Although it is generally understood by courts that the collection of physical evidence, like fingerprints or blood samples, cannot be termed as testimonial compulsion, there have been issues surrounding coerced extraction of biological materials.

Furthermore, Article 14 guarantees equal protection of the law and freedom from arbitrariness on the part of the state. Since there are no set standards for DNA data collection, it can easily become arbitrary or discriminatory against marginalized communities.

In light of the above, DNA profiling in India will have to take into account the state's need to conduct criminal investigations and citizens' right to dignity, autonomy, and privacy.

B. The Bharatiya Sakshya Adhiniyam, 2023 (BSA)

The Bharatiya Sakshya Adhiniyam, 2023 (BSA) acts as the main legal instrument determining the validity of DNA profiling in India. Through the repeal of the British-era Indian Evidence Act, 1872, it aims at upholding evidentiary laws in accordance with developments in science.

²⁸ (2017) 10 SCC 1.

²⁹ See *Selvi v. State of Karnataka*, (2010) 7 SCC 263.

Section 39 of the law clearly acknowledges the relevance of an expert opinion, especially from forensic scientists and DNA analysts. This section lays down the foundation for the admission of DNA profiling reports in the courts³⁰. The use of such evidence, however, is not absolute since it relies on various factors such as scientific validity, proper chain of custody, certification of laboratories, and credible expert witnesses.

In addition, the court often considers DNA evidence as corroboration evidence and not conclusive evidence unless there are high levels of statistical certainty and procedural correctness. It should be noted that even scientifically correct evidence may become invalid if the procedures involved in collecting, preserving, and analyzing it become problematic.

Moreover, DNA evidence is regarded as corroborative evidence unless the statistics and procedures of the testing are solid. The courts have ruled that scientifically accurate evidence will be rendered meaningless when there is a fault in its collection, preservation, and analysis.

The BSA suffers from a major deficiency in Section 116 (the counterpart of Section 112 in the Evidence Act). The statute still upholds the “conclusive proof” of legitimacy, although science has advanced in DNA research³¹. The statute fails to mention DNA testing as an effective means of rebutting the presumption of legitimacy, which places the courts in a difficult situation because they have no other option but to base their decisions on precedent cases.

Thus, while the BSA acknowledges forensic science, it reflects a partial and cautious integration of DNA evidence, leaving certain areas governed by outdated presumptions.

³⁰ The Bharatiya Sakshya Adhinyam, 2023 (Act 47 of 2023), s. 39.

³¹ *Ibid.*, s. 116.

C. The Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS)

The Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS), which has replaced the Code of Criminal Procedure, 1973, sets out the legal procedure for the collection, analysis, and use of evidence from the DNA of the suspect.

In Section 51, BNSS permits the examination of the body of accused persons and further specifies the collection of biological samples required for obtaining the DNA profile of the accused.³² Likewise, Section 184 allows for the medical examination of the victim especially where the offence is one of a sexual nature, to ensure the proper collection of biological evidence.³³

Another noteworthy procedure in the Bharatiya Nagarik Suraksha Sanhita, 2023 is Section 329, which substitutes Section 293 of the CrPC. Reports of the scientific experts of the Government, including DNA analysis conducted by CFSL/SFSL, shall be admissible as evidence without the necessity for the expert to personally appear in court.³⁴

While such an evidentiary provision makes a trial process much more efficient, the question arises regarding its implications, wherein the very process itself might not receive proper cross-examination and could lead to a so-called “trial by lab report.” The said section functions in conjunction with Section 39 of the BSA, 2023, which states that expert opinion constitutes relevant evidence.

Nevertheless, the requirement to provide evidence of certification that the seal on the samples was intact throughout indicates the importance of ensuring the chain of custody, which will require updating to modern technological means of monitoring.

D. The Criminal Procedure (Identification) Act, 2022

The Criminal Procedure (Identification) Act of 2022 is a milestone in the process of criminal identification in India as far as the types of measurable identifiers have been

³² The Bharatiya Nagarik Suraksha Sanhita, 2023 (Act 46 of 2023), s. 51.

³³ *Ibid.*, s. 184.

³⁴ *Ibid.*, s. 329.

increased and biological specimens, including DNA, have been brought within its purview. Replacing the Identification of Prisoners Act of 1920, the Act grants law enforcement bodies the right to collect a variety of information about convicted offenders, as well as persons under arrest or detained within certain categories.

According to the Act, measurements now encompass fingerprints, photographs, as well as biological specimens that may serve as a basis for DNA profiling. Collection may be performed at the request of any member of the police force or prison administration, thus greatly increasing the scope of investigation rights.³⁵

These measurements can also be used to create a DNA profile of the person. Data so collected can be retained and analyzed by the National Crime Records Bureau (NCRB), giving rise to the possibility of establishing an unofficial DNA database system without having any statutory provision for regulating it.³⁶

Nevertheless, the Act has received severe criticism because of its excessively wide scope as well as its lack of sufficient protection measures. The ability to gather information from those people who have only been arrested but not convicted already brings up questions related to the presumption of innocence. Furthermore, the fact that there are no requirements with respect to data retention and deletion mechanisms creates even more grounds for the abuse of the law enforcement authorities.

Constitutionally speaking, it is worth saying that the Act may be subject to criticism in terms of its violations of Articles 21 and 14. The expansive powers granted under the Act, without corresponding safeguards, highlight a growing imbalance between state interests in investigation and individual rights protection.

E. The Digital Personal Data Protection Act, 2023

The Digital Personal Data Protection Act, 2023 (DPDP Act) lays down a framework for the protection of personal data in India, and while it does not directly pertain to the issue

³⁵ The Criminal Procedure (Identification) Act, 2022 (Act 11 of 2022), s. 2(1)(b).

³⁶ *Ibid.*, s. 4(2).

of DNA profiling, it does have several indirect implications on the same. Genetic data comes under the ambit of personal data, which is sensitive due to its nature, being highly related to the identity of an individual.³⁷

The Act is premised on several core principles that include:

1. Lawfulness and fairness
2. Purpose restriction
3. Data minimization
4. Retention limitation and accountability

All these concepts are very applicable to DNA profiling, especially since improper use and excess collection of data may lead to problems like discrimination.

Nevertheless, the potential for the DPDP Act to regulate DNA data is hindered by the wide range of exemptions provided to the State for law enforcement and national security reasons.³⁸ This could permit collecting and processing of DNA data in disregard of the necessity to comply with the principle of informed consent and purpose limitation.

Furthermore, the Act does not cover aspects such as:

1. Creating DNA databases
2. Storing and deleting genetic information
3. Using DNA for purposes other than forensic investigations

The absence of these provisions means that the regulation of DNA profiling occurs at an indirect level as opposed to having specialized legislation to govern this issue.

Although the DPDP Act is a step towards protecting personal data in India, it fails to adequately regulate DNA profiling.

³⁷ The Digital Personal Data Protection Act, 2023 (Act 22 of 2023).

³⁸ *Ibid.*, s. 17.

F. DNA Technology (Use and Application) Regulation Bill, 2019 and its Withdrawal

The DNA Technology (Use and Application) Regulation Bill, 2019 came closest to providing India with a separate legal structure for DNA profiling. With strong reference to the report submitted by the 271st Law Commission, this Bill aimed at regulating the use of DNA samples for particular purposes such as criminal investigations, identification of missing individuals, and disaster victim identification.

Under this legislation, there were provisions for creating a DNA Regulatory Board to supervise DNA testing labs. It also provided for establishing national and regional DNA Data Banks which were required to maintain the DNA profiles under regulation. In addition to that, measures such as limiting the usage, access restrictions, and confidentiality were introduced into the Bill.

Nonetheless, Bill faced considerable backlash from jurists and civil society organizations, who questioned:

1. The potential for mass surveillance and abuse of DNA databanks
2. The absence of adequate data protection protocols
3. The possibility of function creep where the use of DNA evidence might spill over to areas outside its designated scope.³⁹

Eventually, the Bill was shelved, leaving the country without an overarching legislation on DNA profiling. This has led to the emergence of a “post-Bill regulatory void” wherein the collection and analysis of DNA continue via a piecemeal approach through acts like the BNSS Act and the Criminal Procedure (Identification) Act.

Indeed, this is an example of selective implementation, whereby there has been expansion of investigative powers without the establishment of proper checks and balances such as

³⁹ See PRS Legislative Research, ‘The DNA Technology (Use and Application) Regulation Bill, 2019’, available at: <https://prsindia.org/billtrack/the-dna-technology-use-and-application-regulation-bill-2019> (last visited on May 10, 2026).

independence of monitoring bodies, mandatory data erasure, and restrictions on purposes of collection.

XIII. USE OF DNA PROFILING IN THE CRIMINAL INVESTIGATION

Nowadays, DNA testing has proved to be a critical component of any criminal investigation, offering scientists a way of identifying people involved and recreating what actually took place through science. DNA profiling is important in making investigations more accurate and, at the same time, fair because it makes use of tangible evidence as opposed to circumstantial evidence only.

- 1. Identification of Offenders:** DNA profiling has an extensive application in the identification of offenders through the biological samples collected from crime scenes. Biological materials such as blood spots, semen, saliva, and hair root samples can be examined to produce DNA profiles that can be used to identify the offenders. In some cases, when there are no eyewitnesses, DNA profiling can help to create a strong connection between the offender and the criminal act by matching their DNA profile with that found at the crime scene. The accurate results from DNA profiling help in establishing the innocence of offenders in murder and rape crimes.
- 2. Exclusion of Innocent People:** In addition, DNA profiling has the potential to exonerate innocent people from any blame. For instance, if the DNA profile of the suspect does not correspond to that obtained from the crime scene, then it eliminates the suspect completely from the criminal process. DNA profiling has been instrumental in ensuring that wrongful arrests do not occur. Moreover, this objective evidence plays a vital part in preventing the biases of witnesses' testimonies.
- 3. DNA Profiling in Sexual Offences:** In the case of sexual offences, DNA profiling is highly essential since biological material like sperm, vaginal specimens, or epithelial cells is easily available from the body of the suspect. With the aid of technology, it becomes possible to differentiate the mixed DNA sample and

identify the offender despite the complexity of the sample. DNA profiling aids in proving guilt while giving support to the testimony of the victim in a case. Considering the sensitivity of sexual offences, it becomes essential to collect DNA evidence as soon as possible.⁴⁰

4. **Connecting Serial Crimes:** With DNA profiling, it becomes possible for the investigators to link up the various offenses that have been carried out by the same criminal at different places. The presence of identical DNA patterns in separate cases implies that the same offender is involved in all crimes.
5. **Identification of Unknown Corpses:** One of the most important applications of DNA profiling is the identification of unknown or dead corpses, particularly in cases involving murder, accidents, natural calamities, or missing people. Physical characteristics may not help identify an individual, but DNA recovered from the bones, teeth, or tissue samples can be matched with family members to confirm the identity of the deceased individual. In addition to helping solve criminal cases, DNA profiling also helps provide peace of mind to the families of the missing person.⁴¹
6. **Determination of Paternity and Kinship:** In criminal cases, DNA profiling can help establish biological kinship among individuals and prove their identities, which can be helpful in cases of kidnapping, trafficking, or other crimes where the identification of the victim or the perpetrator needs to be confirmed.
7. **Application in Cold Cases:** Thanks to the development in DNA technology, old unsolved cases can be reopened and solved using the previously gathered biological specimens, which are reanalyzed with the application of modern

⁴⁰ D.Q. Mabunda, 'Rape, Sexual Abuse Investigation and the Use of DNA Evidence in the Northern Cape, South Africa' (2025) 12 *Journal of Law, Society and Development* 21 pages, available at: <https://doi.org/10.25159/2520-9515/16030> (last visited on 10 May 2026).

⁴¹ K.M. Reid, H. Suwalowska, L.J. Martin and L.J. Heathfield, 'Ethical Considerations in the Routine Identification of Human Remains in Forensic Mortuaries' (2021) 10 *Wellcome Open Research* 171, available at: <https://wellcomeopenresearch.org/articles/10-171> (last visited on 10 May 2026).

methods to identify suspects years after the crimes occurred. Such advancement has increased the capabilities of forensic investigation substantially.

8. **Use of DNA Databases in Criminal Investigation:** DNA testing helps create forensic databases containing the DNA samples of offenders or unknown samples. Comparison and matching become possible, which increases the speed of investigation. However, building up and using forensic databases raises many ethical and legal issues related to privacy and security of genetic data since there are no effective rules regulating this sphere yet.
9. **Use of DNA Testing to Supplement Evidence in Criminal Trials:** Due to their scientific value, DNA test results serve as a powerful tool for proving the guilt of the accused by confirming other kinds of evidence such as testimonies of witnesses or circumstantial evidence. Nevertheless, DNA evidence is very dependent on proper collection, storage, analysis, and preservation since courts may reject unreliable results.

XIV. EVIDENTIARY VALUE OF DNA PROFILING

In today's world, the use of DNA profiling has become one of the most reliable scientific methods in identifying people involved in criminal activities. This method increases the effectiveness of the process of fact finding in the court due to its high accuracy. However, its admissibility and weight in court depend on compliance with all procedures.

1. **DNA Evidence as Expert Opinion Under Indian Law:** According to the Bharatiya Sakshya Adhiniyam, 2023, DNA profiling can be considered expert evidence and falls into the category of scientific opinion. It means that the courts should evaluate the findings of DNA profiling based on the opinions of the experts and their reports. Nevertheless, the findings cannot be considered conclusive and should be supported by other evidence.
2. **Highly Probative and Reliable:** The reliability of DNA evidence rests on the uniqueness of the DNA composition of each person except for identical twins. The chances that two different people will have an identical DNA profile are very

small, estimated at one in billions. Because of its high accuracy, DNA evidence is highly probative in cases where offenders need to be identified, in sexual cases, and in murder investigations.

3. **Corroborative vs Conclusive Evidence:** Despite its scientific accuracy, DNA profiling is not considered conclusive evidence but rather corroborative evidence in most courts. Its main purpose is to reinforce other types of evidence, including testimonies, circumstantial evidence, and documentation. But there are some situations wherein DNA evidence becomes conclusive, especially when it directly connects the accused with the crime scene or rules out all other possibilities.
4. **Significance of Chain of Custody:** The strength of DNA profiling evidence is greatly determined by the existence of an uninterrupted chain of custody. It includes proper sample collection, sealing, labeling, transport, and preservation. A disruption or anomaly in the process may result in contamination or adulteration, thus undermining the accuracy and validity of the evidence.⁴² The courts examined this issue carefully prior to considering any DNA report.
5. **Forensic Report Evidence (BNSS Perspective):** According to Section 329 of the BNSS, 2023, forensic reports, including DNA profiling reports, may be admitted in court as evidence without having to personally appear. Although the procedure improves efficiency, it reduces the scope for cross-examination. Courts must be careful and call on any expert if deemed necessary.
6. **Limitations that Can Impact Evidentiary Value:** Although DNA evidence is considered highly reliable, it is subject to certain limitations. These limitations include:
 - Contaminated samples
 - Incorrect processing/handling/storing
 - Errors in the laboratory

⁴² T. Hussain and B. Sonowal, 'Evaluating the Efficacy and Constraints of DNA Evidence in the Criminal Justice System in India through Case Studies' (2025) 63(3) *International Annals of Criminology* 591, available at: <https://doi.org/10.1017/cri.2025.10091> (last visited on 10 May 2026).

- Interpretation errors
- Mixed DNA samples

It is important to observe strict rules when dealing with DNA samples as a form of evidence in court.

7. Striking a Balance between Evidentiary Value and Rights: The use of DNA evidence is subject to the provisions of the Constitution, especially the right to privacy as provided in Article 21. The judiciary must take steps to prevent abuse of DNA evidence as a source of evidence. Consequently, although DNA profiling is very useful as evidence, it should be used responsibly and in accordance with the law.

XV. CASE LAWS

A. Nandlal Wasudeo Badwaik v. Lata Nandlal Badwaik (2014)

In this matter, the appellant husband had questioned the validity of a maintenance decree on the grounds that he was not the biological father of the child conceived during the existence of marriage. DNA testing was performed in this regard, which proved beyond doubt that he was not the biological father. Nonetheless, the lower courts applied the presumption of legitimacy under Section 112 of the Indian Evidence Act, 1872 (now Section 116 of the Bharatiya Sakshya Adhinyam, 2023), considering it conclusive proof. The crux of the matter before the Supreme Court lay in whether scientific evidence like DNA profiling could trump this presumption.⁴³

The Supreme Court ruled that while the law does its best to safeguard the principle of social legitimacy, it cannot turn a blind eye to the scientific fact of biological reality. It stated that where there arises a clash between the legal fiction of legitimacy and scientific proof, the latter should always prevail. The Supreme Court therefore favoured DNA evidence over other proofs and concluded that it was unreasonable to compel the

⁴³ (2014) 2 SCC 576.

husband to assume the burden of maintenance of a child who has been scientifically proved not to be his own.

B. Goutam Kundu v. State of West Bengal (1993)

In this case, the husband applied for an order from the court directing the performance of a blood group test for the purpose of negating his claim of being the biological father of the child and consequently to discharge himself from the liability of providing maintenance. The main question posed to the Supreme Court in this case was that of ordering scientific tests for ascertaining paternity in cases where marriage is involved.⁴⁴

The Supreme Court dismissed the notion of conducting scientific tests in all cases and stated that such orders cannot be granted merely on the basis of a “roving inquiry.” The court outlined some significant guidelines wherein the court held that orders relating to scientific tests can be passed only if there exists a *prima facie* case, and further the husband would have to show non-access during the relevant period. It was stressed in this judgment that in determining the issue of paternity in matrimonial matters, it is essential to consider the sanctity of the woman and the legitimacy of the child; scientific tests should not be resorted to without adequate cause because they may lead to disastrous results socially.

C. Mukesh & Ors v. State (NCT of Delhi) (2017) - The Nirbhaya Case

This case involved the horrific rape and murder of a young lady in Delhi in 2012, where a number of people were charged for the crime based on substantial evidence, both forensic and circumstantial. In the course of investigations, biological material obtained from the corpse of the victim, her clothing, and the scene of crime were compared with the DNA profile of the accused. The central issue that arose before the Supreme Court

⁴⁴ (1993) 3 SCC 418.

was whether DNA matching would be enough evidence if corroborated by other evidence to prove the guilt of the accused beyond reasonable doubt.⁴⁵

The Supreme Court affirmed the conviction and stated that the DNA reports were “virtually infallible evidence.” The Court noted that there was an “unassailable link” in the chain of circumstances owing to DNA matching between the profile of the accused and the biological stains present on the possessions of the victim. The Court further emphasized that the DNA evidence, if collected and analyzed properly, has an extremely high probability of correctness, and may lead to the conclusion about the connection between the accused and the crime committed.

D. State of Bombay v. Kathi Kalu Oghad (1961)

The case involved several petitions regarding the collection of physical evidence like fingerprints, handwriting specimens, and signature specimens from the accused persons by the investigating agencies.⁴⁶ The controversy was raised because such evidence had been collected in respect of murder cases, including one involving Kathi Kalu Oghad. The accused persons pleaded that this was contrary to Article 20(3) of the Constitution of India, which guarantees protection from being a witness against oneself.

In its decision, the Supreme Court distinguished between being a witness and furnishing of evidence. According to the judgment, “to be a witness” means communicating personal knowledge through either verbal or written statements, and in doing so the mind is used in some way. On the other hand, furnishing physical characteristics, such as fingerprints, handwriting, and biological specimens, does not involve any communication whatsoever. Furthermore, the Court pointed out that such specimens were “immutable” and existed independently of the person’s will and volition.

Thus, the Court held that the requirement for the accused to give samples of his body or biological material was not in violation of Article 20(3), since there was no question of

⁴⁵ (2017) 6 SCC 1.

⁴⁶ AIR 1961 SC 1808.

any testimony being extracted from him. This decision lays down the constitutional basis of forensic evidence in India, which is often cited in support of the constitutionality of DNA analysis, as DNA samples are considered physical evidence like fingerprints.

Thus, the Court held that the requirement for the accused to give samples of his body or biological material was not in violation of Article 20(3), since there was no question of any testimony being extracted from him. This decision lays down the constitutional basis of forensic evidence in India, which is often cited in support of the constitutionality of DNA analysis, as DNA samples are considered physical evidence like fingerprints.

E. *Aparna Ajinkya Firodia v. Ajinkya Firodia* (2023)

In this case, the husband filed for divorce on the grounds of adultery where he accused his wife of having an affair outside marriage and not being the father of his child. To establish this, he requested for an order that would require him to undertake a DNA test of his child. This request was granted in the High Court. In response, the wife appealed against the ruling in the Supreme Court arguing the issue of the child's welfare and the presumption of legitimacy. The key issues at stake in this case were whether a DNA test can be ordered as a matter of course in proof of adultery, the balance between the presumption of legitimacy of Section 112 of the Evidence Act (Section 116 of BSA, 2023), and scientific evidence, and whether forcing the child to take the DNA test infringes the right to dignity.⁴⁷

The Supreme Court upheld the appeal filed by the wife and declared the order directing DNA testing as null and void. In its decision, the court reiterated that the presumption of legitimacy under Section 112 is a very strong presumption and conclusive in nature; it cannot be rebutted through DNA testing unless the husband can first prove non-access. The court further stressed that the welfare of the child should be considered, noting that DNA testing in cases of marriage litigation may lead to discrimination and psychological damage against the child, thus making the latter feel like a "pawn." Additionally, DNA

⁴⁷ 2023 SCC OnLine SC 161.

testing entails the right to privacy, which includes the privacy of one's genetic data; hence, courts should adopt "eminent restraint" before ordering DNA testing. Allegations of adultery could likewise be proven using alternative evidence apart from DNA testing.

XVI. CRITICAL ANALYSIS AND CHALLENGES OF DNA PROFILING IN INDIA

In spite of being a scientifically accurate method, DNA profiling encounters numerous legal, constitutional, and administrative barriers in India. One such obstacle is the lack of consolidated legislation governing DNA testing, leading to a patchwork approach based on various statutes, including BSA, BNSS, and the Criminal Procedure (Identification) Act. The withdrawal of the DNA Technology Regulation Bill, 2019 has led to what is referred to as the creation of "regulatory vacuum."

The other important point of concern pertains to the right to privacy and protection of data, as DNA profiles are extremely personal information, whose collection involves right to privacy enshrined under Article 21 in the case of Justice K.S. Puttaswamy v. Union of India. Without appropriate security measures in place, however, it would be difficult to rule out the danger of abuse, unauthorized use, and function creep owing to the increasing power of the state to gather biological information.

Moreover, issues related to procedures such as poor chain of custody and the use of conventional techniques are associated with the dangers of contamination and interference. The clause within Section 329 of BNSS which allows forensic reports to be admitted into court without any evidence from an expert may result in what can be termed as "trial by lab report," thereby hindering adequate cross-examination.

Other issues of ethics include consent, respect, and stigmatization, among other concerns especially when dealing with children or cases of paternity suits. There is the existence of a legality-reality dichotomy due to the conflict between old legal presumptions and scientifically valid DNA evidence.

Therefore, even though the DNA profiling process is quite effective in investigations, for its effective utilization, there must be a harmonious blend of the legal system.

XVII. SUGGESTIONS

For proper utilization of the DNA profiling technology in India, there is a need for a complete legal regime. Firstly, there is a pressing need for the introduction of specific DNA legislation that adopts measures recommended by the Law Commission in its 271st report like creation of a DNA Regulatory Board, laboratory accreditation, and guidelines on sample collection, storage, and analysis.

Secondly, there should be measures to protect the data obtained through DNA profiling, with regard to concepts like informed consent, data minimization, purpose restriction, and deletion of data in case of acquittal or charges against the suspect. This will bring DNA profiling in compliance with Article 21 of the Indian Constitution.

Thirdly, the implementation of the Digital Chain of Custody framework is imperative to guarantee integrity, traceability, and avoid tampering with biological specimens. The move would significantly boost the credibility of DNA evidence in court.

Moreover, there should be judicial restraint by the courts in issuing orders for DNA testing in special cases, such as those that involve minors or family disputes. There should also be training and capacity development of forensic practitioners, law enforcers, and judicial officials in dealing with DNA evidence.

Finally, the establishment of a DNA database framework under the supervision of an independent body is critical.

XVIII. CONCLUSION

The use of DNA profiling in forensic investigations is truly revolutionary as far as accuracy and efficiency in identifying criminals go. Increasing acceptance of DNA profiling by the judiciary in India clearly signifies a move toward scientific and rational approach in justice delivery.

But such an advanced forensic tool needs to be used with care and discretion. Although there is a developing trend towards regulation of the use of this technology, the present legal mechanism is grossly inadequate in dealing with issues surrounding DNA profiling, particularly those related to privacy and other legal concerns. In other words, the development of DNA profiling technologies seems to be at odds with constitutional guarantees.

In that context, the way forward for DNA profiling in India will involve finding a proper equilibrium between technological advance on the one hand and legal and constitutional norms on the other.

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