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Role Of Scientific Evidence In Criminal Justice Administration

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Abstract

Scientific evidence plays a crucial role in modern criminal justice systems, ensuring that convictions are based on objective facts rather than solely on witness testimony or circumstantial evidence. This dissertation examines the role of scientific evidence in criminal justice administration, with a specific focus on India while drawing comparisons with the United States and the United Kingdom. The study explores various forensic techniques, including DNA analysis, fingerprint examination, ballistic tests, and digital forensics, and their impact on criminal investigations and trials. It further discusses the legal and procedural aspects of forensic evidence under Indian law, as well as the challenges faced in its admissibility, reliability, and interpretation. A comparative analysis with the U.S. and U.K. highlights how different jurisdictions regulate forensic science and establish its credibility in court. Key issues such as lack of forensic infrastructure, judicial reluctance in accepting forensic reports, expert bias, and procedural delays are critically analyzed. The study also addresses emerging challenges, including the rise of digital crimes and the role of artificial intelligence in forensic investigations. The dissertation concludes by recommending legal reforms, improvements in forensic infrastructure, judicial training, and enhanced forensic regulations to strengthen the use of scientific evidence in India's criminal justice system. These reforms would help ensure that forensic evidence contributes effectively to fair trials, speedy justice, and accurate convictions.

Keywords: *Scientific Evidence, Forensic Science, Criminal Justice, DNA Profiling, Digital Forensics, Fingerprint Analysis, Ballistics*

INTRODUCTION

Scientific evidence has become an essential tool in criminal justice administration. It helps law enforcement agencies and courts determine the guilt or innocence of an accused person through objective and verifiable facts. Over the years, advancements in forensic science have played a crucial role in solving crimes and ensuring justice. Scientific techniques such as DNA profiling, fingerprint analysis, ballistics tests, and digital forensics have significantly improved the accuracy and efficiency of criminal investigations. These techniques provide factual evidence that helps reduce wrongful convictions and ensures that guilty individuals are held accountable.

In India, the role of scientific evidence has gained importance with the introduction of the Bharatiya Sakshya Adhiniyam, 2023, which replaces the Indian Evidence Act, 1872. This new law aims to modernize the rules regarding the admissibility and weight of forensic evidence in trials. However, despite these developments, the full potential of forensic science is not yet realized in India. Several issues hinder the effective use of scientific evidence in criminal trials, including limited forensic infrastructure, delays in forensic reports, lack of trained professionals, judicial reluctance, and procedural barriers.

A comparative analysis of India's legal framework with that of the United States and the United Kingdom provides insights into best practices that India can adopt. The U.S. follows the Daubert standard, which requires judges to assess the reliability and relevance of scientific evidence before admitting it in court. This standard was established in *Daubert v Merrell Dow Pharmaceuticals, Inc*, 509 US 579 (1993). Meanwhile, the United Kingdom follows the Police and Criminal Evidence Act (PACE) 1984, which regulates the collection and use of forensic evidence in criminal cases. Both countries have well-developed forensic systems and legal standards that ensure the reliability of scientific evidence.

By studying how these countries utilize forensic science, this dissertation aims to highlight reforms that can enhance the reliability and admissibility of scientific evidence in India's criminal justice system. Strengthening forensic infrastructure, improving the training of forensic experts, and ensuring judicial acceptance of forensic science are key areas that need attention.

IMPORTANCE OF SCIENTIFIC EVIDENCE IN CRIMINAL JUSTICE

Scientific evidence is crucial in criminal cases as it provides objective information that supports or refutes claims made by the prosecution and defense. Unlike oral testimony, which can be influenced by human error, bias, or falsehoods, scientific evidence is based on verifiable facts. It helps investigators identify suspects, establish links between the accused and the crime scene, and

reconstruct the sequence of events.

Some of the most widely used forensic techniques include:

1. **DNA Profiling** – DNA analysis helps in identifying suspects by matching biological samples found at a crime scene with those of the accused. DNA evidence is considered one of the most reliable forensic techniques.
2. **Fingerprint Analysis** – Fingerprints are unique to individuals, making fingerprint evidence an important tool for identifying suspects.
3. **Ballistics Tests** – These tests help determine whether a particular firearm was used in a crime. They analyze bullet trajectories, gunpowder residue, and firearm markings.
4. **Digital Forensics** – With the rise of cybercrimes, digital forensics is becoming increasingly important. It involves analyzing electronic devices, emails, call records, and encrypted files to gather evidence.
5. **Toxicology Reports** – These reports help in identifying poisons, drugs, or alcohol in a person's body, which can be crucial in cases of poisoning, drug overdose, or impaired driving.

Scientific evidence plays a key role in reducing wrongful convictions. Several cases in India and other countries have shown that forensic science has helped in exonerating innocent individuals who were wrongfully accused. However, to ensure that scientific evidence is used effectively, the legal system must have clear guidelines on its collection, preservation, and admissibility in court.

EVIDENCE IN THE INDIAN LEGAL SYSTEM

India has recognized the importance of scientific evidence in criminal trials, but its forensic system still faces significant challenges. The Bharatiya Sakshya Adhiniyam, 2023 aims to modernize India's evidentiary laws and provide clear rules on the admissibility of forensic evidence. However, there are several obstacles to the effective use of scientific evidence in India, including:

1. Limited Forensic Infrastructure

India has a shortage of well-equipped forensic laboratories and trained forensic experts. Many forensic labs in the country suffer from outdated technology, inadequate resources, and a high backlog of cases. The delay in forensic reports affects the timely conclusion of trials.

2. Procedural Delays

In India, criminal trials often take years to conclude, and forensic evidence is sometimes not presented in court due to delays in obtaining reports. The slow processing of forensic samples reduces the impact of scientific evidence in criminal cases.

3. Judicial Reluctance

Judges and lawyers in India are sometimes reluctant to rely on forensic evidence due to a lack of technical knowledge. Unlike in the U.S. and the U.K., where judges actively assess the reliability of scientific methods, Indian courts often place more emphasis on eyewitness testimony.

4. Issues in Collection and Handling of Evidence

Forensic evidence must be collected, preserved, and analyzed properly to maintain its integrity. In many cases, forensic samples in India are not stored under proper conditions, leading to contamination or loss of evidence.

CONCEPT AND EVOLUTION OF SCIENTIFIC EVIDENCE

Scientific evidence plays a crucial role in modern criminal justice systems. Unlike traditional forms of evidence such as witness testimonies and confessions, scientific evidence is based on empirical data, laboratory analysis, and expert opinions. This ensures that the legal process relies on objective and verifiable facts rather than human memory, which may be unreliable. Over the years, forensic science has advanced significantly, from early fingerprint identification methods to complex DNA analysis, ballistics tests, and digital forensics. These scientific techniques have improved the accuracy of criminal investigations and have helped in proving or disproving allegations with a higher degree of certainty. However, the use of forensic evidence also raises concerns about its admissibility, reliability, and ethical implications. Courts must ensure that forensic techniques meet legal standards, are scientifically valid, and are applied without bias or manipulation.

The evolution of scientific evidence has shaped the way criminal investigations are conducted. In the early stages, forensic science relied on basic techniques such as fingerprint identification and handwriting analysis. However, with advancements in technology, more sophisticated methods have emerged. DNA profiling has revolutionized criminal justice by providing a nearly foolproof way to establish identity and link suspects to crime scenes. Ballistic examinations help determine whether a specific firearm was used in a crime, while forensic toxicology assists in detecting poisons, drugs, and other substances in the human body. Digital forensics has also gained importance in recent

years, especially with the rise in cybercrimes, where electronic data, mobile records, and computer logs serve as critical evidence. Despite these advancements, forensic science is not without limitations. Contamination of evidence, human errors, and biased interpretations can undermine the credibility of forensic findings. Additionally, the lack of proper forensic infrastructure and delays in forensic examinations remain a major challenge in many legal systems.

The use of scientific evidence varies across different legal systems. In India, the importance of forensic science has increased with the introduction of the Bharatiya Sakshya Adhiniyam, 2023, which replaces the Indian Evidence Act, 1872. This law aims to modernize the admissibility and evaluation of forensic evidence in court trials.

However, challenges such as insufficient forensic labs, shortage of trained experts, and judicial reluctance to fully rely on scientific evidence hinder its effectiveness. In contrast, the United States follows the Daubert standard, which requires judges to assess the reliability and relevance of scientific evidence before admitting it in court. This approach ensures that only scientifically valid evidence is considered in legal proceedings (*Daubert v Merrell Dow Pharmaceuticals, Inc*, 509 US 579 (1993)). Meanwhile, the United Kingdom follows the Police and Criminal Evidence Act (PACE) 1984, which regulates forensic evidence collection and sets guidelines for expert testimony. Both the U.S. and the U.K. have well-established forensic systems, with stringent rules governing the handling, preservation, and presentation of forensic findings. India can learn from these countries to improve its forensic framework, invest in modern technology, and ensure proper training of forensic experts.

Scientific evidence has transformed criminal justice by making investigations more accurate and evidence-based. It provides objective and reliable information that helps in establishing guilt or innocence. However, challenges such as the proper collection, interpretation, and admissibility of forensic evidence must be addressed to prevent wrongful convictions and ensure fair trials. The comparison of forensic practices in India, the U.S., and the U.K. highlights the need for legal reforms, better infrastructure, and standardized procedures in India's forensic system. Strengthening forensic capabilities and ensuring their proper use in trials will enhance the credibility and efficiency of the criminal justice system.

DEFINITION AND CHARACTERISTICS OF SCIENTIFIC EVIDENCE

Meaning of Scientific Evidence

Scientific evidence refers to any **information, analysis, or expert testimony based on scientific**

principles that is presented in a court of law. It includes results from forensic examinations such as:

- **DNA profiling** (used in identifying individuals in criminal cases).
- **Fingerprint analysis** (matching fingerprints found at crime scenes).
- **Ballistic testing** (analyzing firearms and bullet trajectories).
- **Toxicology reports** (detecting poisons or drugs in a person's system).
- **Digital forensics** (recovering data from electronic devices).

Scientific evidence is often presented through **expert witnesses** who interpret and explain findings to the court. Under **Indian law**, such evidence is governed by the **Bharatiya Sakshya Adhiniyam, 2023**, which lays down rules for admissibility and expert testimony.

Characteristics of Scientific Evidence

Scientific evidence is distinct from other types of legal evidence because it must meet the following criteria:

1. **Empirical Basis:** Scientific evidence must be based on **experiments, observations, and established scientific principles.**
2. **Objectivity:** It must be free from **bias, speculation, or personal opinions.**
3. **Reproducibility:** Any scientific test used must yield **consistent results** when conducted under similar conditions.
4. **Admissibility Standards:** Courts determine whether forensic evidence is **reliable and relevant** before accepting it in trials.

In India, forensic evidence must comply with legal provisions under the **Bharatiya Sakshya Adhiniyam, 2023**. In the U.S., courts follow the **Daubert standard**, which assesses whether forensic techniques are **scientifically valid** [Daubert v Merrell Dow Pharmaceuticals, Inc, 509 US 579 (1993)].

Evolution of Scientific Evidence in Criminal Justice

Early Methods of Criminal Investigation

The use of scientific evidence in criminal investigations has evolved over centuries, influenced by technological progress and legal reforms. Earlier, criminal cases were largely decided based on witness statements, confessions, and circumstantial evidence. However, these methods were often unreliable, as they depended on human memory, perception, and interpretation, which could be flawed. Many wrongful convictions occurred due to coerced confessions or mistaken witness identifications. The introduction of forensic science changed this approach by providing objective, scientific methods to establish facts. Over time, forensic techniques have developed, allowing investigators to analyze physical evidence with greater precision. From simple fingerprint identification to complex DNA profiling and digital forensics, the growth of forensic science has transformed criminal investigations worldwide.

In the early days of crime detection, there were no scientific tools to confirm evidence. Investigators relied on basic observations, witness accounts, and sometimes even superstitious beliefs. As criminal cases became more complex, the need for a more systematic approach led to the development of forensic science. One of the earliest forensic methods was fingerprint identification, which gained importance in the 19th century. Sir William Herschel, a British officer in India, was among the first to use fingerprints for personal identification in 1858. His observations led to further studies, and Sir Francis Galton later proved that fingerprints are unique to every individual. This discovery helped in linking suspects to crime scenes with greater accuracy. The first criminal case where fingerprint evidence was used to secure a conviction occurred in Argentina in 1892. This marked the beginning of forensic fingerprint analysis as an essential part of crime investigations.

Another major breakthrough in forensic science was toxicology, which emerged in the 19th century. Before the development of scientific methods, poisoning cases were difficult to prove, as there was no reliable way to detect harmful substances in the human body. In 1814, a method known as the Marsh Test was created to detect arsenic, one of the most commonly used poisons at the time. This test allowed forensic experts to confirm whether a person had been poisoned. In 1836, James Marsh applied this technique in a murder trial, successfully demonstrating the presence of arsenic in a corpse. This case set a precedent for the use of toxicology in criminal trials. Over time, forensic toxicology expanded to include the detection of various poisons, drugs, and alcohol levels in the human body. Today, it is widely used in cases involving drug overdoses, alcohol-related offenses, and suspicious deaths.

The 20th century saw further advancements in forensic science, particularly in ballistics and firearm analysis. Before the introduction of scientific methods, investigators determined whether a gun was used in a crime by comparing bullets through visual examination. This approach lacked precision and often led to incorrect conclusions. In 1925, Calvin Goddard developed the comparison microscope, a revolutionary tool that allowed forensic experts to compare bullets and cartridge casings under high magnification. This technique helped match bullets to specific firearms with great accuracy. One of the first major cases where this method was used was the St. Valentine's Day Massacre in 1929. In this case, forensic experts linked bullets found at the crime scene to weapons used by gang members, providing crucial evidence in the investigation. Since then, ballistic analysis has become a fundamental part of criminal investigations, helping solve cases involving gun violence and organized crime.

Types of Scientific Evidence Used in Criminal Cases

Scientific evidence is one of the most crucial components of modern criminal investigations. It helps law enforcement agencies uncover facts, identify perpetrators, and ensure justice is served. Unlike eyewitness testimony, which can be unreliable due to memory lapses or biases, scientific evidence is based on objective analysis. Over the years, forensic science has evolved to include multiple disciplines, each specializing in different types of physical and digital evidence. This section explores the various types of scientific evidence commonly used in criminal cases.

DNA Evidence

DNA (Deoxyribonucleic Acid) analysis is one of the most reliable forensic tools in criminal investigations. It is widely used for suspect identification, linking perpetrators to crime scenes, and exonerating the wrongfully accused. Since every individual (except identical twins) has a unique DNA profile, DNA analysis provides highly accurate results.

Key Aspects of DNA Evidence

1. Individual Identification – DNA profiling is a scientific method that helps distinguish one person from another with high precision. Even small biological samples, such as hair, saliva, or skin cells, can be analyzed to determine identity.
2. Crime Scene Analysis – DNA recovered from crime scenes can help establish a suspect's presence or eliminate an innocent person from suspicion. This is particularly useful in sexual assault and homicide cases, where biological evidence is often found.

3. DNA Databases – Many countries have national DNA databases that store genetic information to solve cold cases. The U.S. maintains the Combined DNA Index System (CODIS), while the U.K. operates the National DNA Database (NDNAD). These databases help law enforcement agencies match unidentified DNA profiles with known offenders.

Legal Position in India

- DNA evidence is admissible in court under the Bharatiya Sakshya Adhiniyam, 2023.¹
- The Supreme Court in *Kishanbhai v State of Gujarat* (2014) 5 SCC 108 emphasized the importance of DNA analysis in ensuring justice².
- India has proposed the DNA Technology (Use and Application) Regulation Bill, which aims to create a national DNA database for crime investigations.

Ballistic and Firearm Examination

Ballistic analysis is used to examine firearms, ammunition, and bullet trajectories to determine the origin and nature of gun-related crimes. It helps answer key questions such as:

- Was a specific firearm used in the crime?
- What was the range and angle of fire?
- Has the weapon been recently used?

Ballistic analysis played a crucial role in the Rajiv Gandhi assassination case (1991), where forensic experts traced the firearm used in the attack³. The study of gunshot residues, cartridge marks, and bullet fragments also provides valuable leads in homicide cases.

Forensic Toxicology

Forensic toxicology involves the detection of poisons, drugs, and chemicals in biological samples. It is widely used in:

¹ Ministry of Law and Justice, Government of India, *Bharatiya Nyaya Sanhita*, 2023; *Bharatiya Nagarik Suraksha Sanhita*, 2023; and *Bharatiya Sakshya Adhiniyam*, 2023 (*Amended Criminal Laws*) (CDTI Hyderabad, 2023) https://cdtihyd.gov.in/static/download/LatestLaws/amended_criminal_laws.pdf accessed 24 April 2025

² *State of Gujarat v Kishanbhai* (2014) 5 SCC 108 <https://supremetoday.ai/issue/Kishanbhai-vs-state-of-gujarat> accessed 24 April 2025

³ Jain Commission of Inquiry, *Final Report on the Assassination of Shri Rajiv Gandhi, Former Prime Minister of India on 21st May, 1991 at Sriperumbudur*, vol 2, Chapters 1–6 (7 March 1998) <https://elibrary.sansad.in/items/cf80a767-d175-4a84-8d7e-3402d1151799> accessed 24 April 2025

- Poisoning Cases – Identifying toxic substances like cyanide, arsenic, or pesticides in a victim's body.⁴
- Drug-Related Crimes – Detecting narcotics in suspects' blood or urine samples.
- Alcohol Testing – Conducting breathalyzer tests in cases of drunk driving (DUI).

Indian Legal Provisions

- Toxicology reports are admissible as scientific evidence under the Bharatiya Sakshya Adhiniyam, 2023.
- The Narcotic Drugs and Psychotropic Substances Act, 1985 (NDPS Act) governs drug-related forensic investigations in India.⁵

2.4.5 Digital Forensics

With the rise of cybercrime, digital forensics has become a critical tool in criminal investigations. It involves:

- Recovering Deleted Files and Messages – Used in financial frauds, hacking, and cyberstalking cases.
- Tracing Cyber Frauds – Identifying IP addresses and tracking illegal transactions.
- Analyzing Digital Footprints – Monitoring social media, emails, and browsing histories to detect criminal activity.

Legal Position in India

- The Information Technology Act, 2000 provides a legal framework for cyber forensics and digital evidence collection.⁶
- Digital evidence is now admissible under Bharatiya Sakshya Adhiniyam, 2023⁷

⁴ ScienceDirect, 'Forensic Toxicology Analysis' (ScienceDirect) <https://www.sciencedirect.com/topics/medicine-and-dentistry/forensic-toxicology-analysis> accessed 24 April 2025

⁵ P Parmar and G Rathod, 'Understanding the Narcotic Drugs and Psychotropic Substances Act in India: A Comprehensive Analysis' (2024) 9(1) *Advances in Clinical Toxicology* 000296 <https://medwinpublishers.com/ACT/understanding-the-narcotic-drugs-and-psychotropic-substances--act-in-india-a-comprehensive-analysis.pdf> accessed 24 April 2025

⁶ Tamil Nadu Dr. Ambedkar Law University, *Cyber Law and Forensics* (e-content module, TNDALU) https://tndalu.ac.in/econtent/15_Cyber_Law_And_Forensics.pdf accessed 24 April 2025

⁷ Smt. Sk. Shireen, *Electronic Evidence* (Paper Presentation, V Additional Civil Judge (Junior Division) Cum V Additional Judicial Magistrate of First Class, Kakinada)

2.4.6 Psychological and Behavioral Profiling

Criminal profiling is an investigative tool that helps law enforcement understand offender behavior. It involves:

- Psychological Autopsy – Studying the mental state of suicide victims to determine intent.
- Lie Detector Tests – Polygraph and narco-analysis, which analyze physiological responses to detect deception. However, these tests can only be conducted with the accused's consent, as per *Selvi v State of Karnataka* (2010) 7 SCC 263.⁸

Behavioral analysis is also used in terrorism investigations, serial offender profiling, and hostage negotiations.

Admissibility of Scientific Evidence in Courts

The admissibility of scientific evidence in criminal trials depends on its reliability, relevance, and compliance with legal standards. Courts must ensure that forensic evidence is scientifically valid, lawfully obtained, and properly interpreted before being used in legal proceedings. Scientific evidence has played a crucial role in securing convictions and exonerating the wrongly accused, making its admissibility a critical aspect of criminal justice administration.

This section examines the principles governing the admissibility of scientific evidence in India, the U.S., and the U.K. while also addressing key challenges associated with forensic evidence in courts.

LEGAL FRAMEWORK FOR ADMISSIBILITY IN INDIA

In India, scientific evidence is admissible under the Bharatiya Sakshya Adhiniyam, 2023, which replaced the Indian Evidence Act, 1872. The new law explicitly recognizes forensic techniques, including DNA analysis, digital evidence, fingerprint examination, and toxicology reports. The legal system emphasizes that forensic evidence must be relevant, reliable, and obtained lawfully before being admitted in court.

Key Provisions for Scientific Evidence in India

The Bharatiya Sakshya Adhiniyam, 2023, provides specific provisions for the admissibility of forensic evidence:

<https://cdnbbsr.s3waas.gov.in/s3ec01a0ba2648acd23dc7a5829968ce53/uploads/2024/12/2024122766.pdf> accessed 24 April 2025

⁸ Gazala Parveen, 'Right to Remain Silent: Case Commentary – Smt. Selvi v State of Karnataka' (iPleaders, 22 March 2024) <https://blog.ipleaders.in/right-remain-silent-case-commentary-smt-selvi-v-state-karnataka/> accessed 24 April 2025

- Section 61 – Governs expert testimony, requiring forensic experts to provide their findings in court ⁹.
- Section 63 – Allows courts to admit electronic and digital records as evidence, making cyber forensics legally admissible.
- Section 75 – Recognizes forensic reports as admissible evidence, provided they meet procedural and evidentiary standards.

These provisions ensure that forensic science plays a legally recognized role in criminal trials, strengthening the reliability of evidence presented in courts.

Judicial Approach in India

Indian courts have relied on forensic evidence in several landmark cases but also emphasize the importance of procedural safeguards. Some key judicial pronouncements include:

- **Selvi v State of Karnataka** ¹⁰– The Supreme Court ruled that narco-analysis and polygraph tests cannot be conducted without the accused's consent, citing Article 20(3) of the Constitution, which protects against self-incrimination.
- **State of Gujarat v Kishanbhai** – The Supreme Court stressed the necessity of DNA testing in criminal investigations, stating that forensic evidence must be collected and analyzed in accordance with legal standards ¹¹.
- **Mukesh & Anr v State for NCT of Delhi (Nirbhaya case)** – The use of forensic evidence, including DNA analysis and fingerprint matching, played a critical role in securing convictions¹².

These rulings reflect India's growing reliance on forensic science while also ensuring that evidence is obtained fairly and in compliance with constitutional protections.

2.5.2 Standards for Admissibility in the U.S.

The United States follows two key legal standards for admitting forensic evidence:

⁹ LegallyIn, 'Sections 61, 62, and 63 of the Bharatiya Sakshya Adhiniyam (BSA): Admissibility of Electronic Records' (29 September 2024) <https://legallyin.com/sections-61-62-and-63-of-the-bharatiya-sakshya-adhiniyambsa-admissibility-of-electronic-records/> accessed 24 April 2025

¹⁰ **Selvi v State of Karnataka (2010) 7 SCC 263** .

¹¹ **State of Gujarat v Kishanbhai (2014) 5 SCC 108**.

¹² **Mukesh & Anr v State for NCT of Delhi (2017) 6 SCC 1**.

1. Frye Standard (1923) – Established in **Frye v United States, 293 F 1013 (DC Cir 1923)**, this rule states that scientific techniques must be "generally accepted" by the relevant scientific community before they can be admitted as evidence.¹³
2. Daubert Standard (1993) – In **Daubert v Merrell Dow Pharmaceuticals, Inc, 509 US 579 (1993)**, the U.S. Supreme Court ruled that judges must act as gatekeepers, ensuring that scientific evidence is based on reliable principles and methodologies.¹⁴

Key Considerations Under the Daubert Standard

Courts apply five key factors to determine whether forensic evidence is admissible:

1. Testing – Has the forensic method been tested under controlled conditions?
2. Peer Review – Has the technique been reviewed and accepted by experts in the field?
3. Error Rate – Does the method have a known error rate, and is it within acceptable limits?
4. Standards and Protocols – Are there established protocols that ensure reliability?
5. General Acceptance – Is the method widely accepted in the scientific community?

The FBI's forensic laboratory follows these principles, ensuring that forensic reports meet Daubert reliability criteria before being used in trials.

ADMISSIBILITY OF SCIENTIFIC EVIDENCE IN THE U.K.

The United Kingdom applies a combination of common law principles and statutory provisions to determine the admissibility of forensic evidence.

Legal Framework in the U.K.

- The Police and Criminal Evidence Act (PACE), 1984 – Sections 76–78 govern the collection and admissibility of forensic evidence, ensuring that evidence is obtained lawfully.¹⁵

¹³ Anjelica Cappellino, 'Admitting Expert Testimony Under the Frye Standard: The Ultimate Guide' (Expert Institute, 9 July 2024) <https://www.expertinstitute.com/resources/insights/admitting-expert-testimony-under-the-frye-standard-the-ultimate-guide/#:~:text=The%20general%20premise%20in%20Frye,in%20the%20relevant%20scientific%20community.> accessed 24 April 2025

¹⁴ Alexis Abboud, 'Daubert v. Merrell Dow Pharmaceuticals, Inc. (1993)' (Embryo Project Encyclopedia, 29 May 2017) <https://embryo.asu.edu/pages/daubert-v-merrell-dow-pharmaceuticals-inc-1993> accessed 24 April 2025

¹⁵ Police and Criminal Evidence Act 1984, s 76 <https://www.legislation.gov.uk/ukpga/1984/60/section/76> accessed 24 April 2025

- Criminal Procedure Rules, 2015 – Set out procedures for presenting forensic reports and expert testimony in court.

Judicial Approach in the U.K.

- R v Doheny & Adams– Established the Doheny & Adams test, which ensures that forensic evidence is scientifically validated before being admitted in court.
- R v T– The Court of Appeal ruled that forensic evidence must be based on rigorous scientific analysis.
- R v Clarke – Stressed the importance of expert witnesses in presenting forensic findings.

These cases highlight the U.K.'s cautious approach to forensic evidence, ensuring that scientific methods are credible and legally sound.

CHALLENGES IN ADMITTING FORENSIC EVIDENCE

Despite its significance, forensic evidence faces several challenges in courts:

1. Risk of Contamination – Mishandling of DNA, fingerprints, and other forensic samples can lead to wrongful convictions.
2. Questionable Reliability of Some Techniques – Some forensic methods, such as bite mark analysis and hair comparison, lack scientific validation.
3. Bias in Expert Testimony – Forensic experts may unintentionally present biased interpretations, favoring the prosecution or defense.
4. Backlog in Forensic Labs – Delays in forensic analysis due to high caseloads can slow down trials and affect justice delivery.

PROCEDURAL ASPECTS OF SCIENTIFIC EVIDENCE IN CRIMINAL INVESTIGATIONS AND TRIALS

Scientific evidence is an essential part of modern criminal justice systems. It helps investigators and courts establish facts, identify offenders, and ensure justice. Forensic evidence includes DNA analysis, fingerprint examination, digital evidence, ballistic reports, and toxicology tests. These scientific methods provide objective and reliable proof, reducing the chances of wrongful convictions based on circumstantial or unreliable witness testimony.

However, forensic evidence is not automatically accepted in court just because it is scientific. It must be collected, preserved, and presented according to strict legal and procedural rules. If forensic evidence is mishandled, contaminated, or obtained unlawfully, it may be inadmissible in court. Legal safeguards are necessary to prevent tampering, manipulation, or false expert opinions that could influence judicial decisions. Courts must ensure that scientific evidence meets legal standards of authenticity, reliability, and relevance before considering it in criminal trials.

The procedural aspects of forensic evidence involve multiple stages:

1. Collection and Preservation of Forensic Material – Investigators must collect evidence using standard forensic protocols to prevent contamination. DNA, fingerprints, and digital records must be stored securely to maintain their integrity.
2. Analysis and Authentication by Forensic Experts – Only qualified forensic scientists should analyze evidence. They must follow scientific methods and ethical standards to ensure accurate results.
3. Presentation in Court – Forensic experts may be called to testify about their findings. Courts examine whether forensic reports meet evidentiary requirements and whether expert testimony is credible and unbiased.
4. Judicial Scrutiny and Admissibility Standards – Judges assess forensic evidence using legal tests to determine whether it is scientifically valid and legally permissible. Different countries apply different standards for admissibility. Legal Framework in India and Other Jurisdictions

In India, forensic procedures are governed by:

- Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS) – This law replaces the Criminal Procedure Code (CrPC) and lays down rules for collecting and using forensic evidence in investigations.
- Bharatiya Sakshya Adhiniyam, 2023 (BSA) – Replacing the Indian Evidence Act, 1872, this law sets guidelines on admitting forensic reports and expert opinions in court.
- Other Laws – Regulations like the DNA Technology (Use and Application) Regulation Bill, 2019, govern DNA profiling in criminal cases.

In the United States, courts follow the Daubert Standard, which requires forensic evidence to be scientifically tested, peer-reviewed, and widely accepted before being used in court. This standard

was established in **Daubert v Merrell Dow Pharmaceuticals**¹⁶

In the United Kingdom, forensic evidence is evaluated under the Doheny & Adams test, which was laid down in **R v Doheny & Adams**¹⁷. This test ensures that forensic methods are scientifically valid and applied correctly in trials.

Collection and Preservation of Scientific Evidence

The reliability of scientific evidence in criminal cases largely depends on its proper collection, preservation, and handling. Any lapse in these processes can lead to contamination, tampering, or loss of crucial evidence, which may affect its admissibility in court. Law enforcement agencies must follow strict legal and scientific protocols to ensure that forensic evidence remains credible and legally valid.

LEGAL FRAMEWORK GOVERNING COLLECTION AND PRESERVATION

In India, the collection and handling of forensic evidence are primarily governed by the Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS), the Bharatiya Sakshya Adhiniyam, 2023 (BSA), and various forensic guidelines issued by investigative agencies. Key provisions include:

Section 175 of BNSS – Grants police officers the authority to collect physical and forensic evidence from crime scenes.

- Section 63 of BSA – Recognizes electronic records and digital evidence as admissible, provided they are properly preserved.
- Forensic Guidelines by CFSLS & FSLs – The Central Forensic Science Laboratory (CFSL) and state-level Forensic Science Laboratories (FSLs) issue standard operating procedures (SOPs) for handling forensic samples.

In the United States, forensic evidence must comply with the Fourth Amendment, which protects against unlawful searches and seizures. The Federal Rules of Evidence (FRE), along with the Daubert Standard, ensure that evidence collected is scientifically reliable and legally admissible. The U.K. follows similar procedures, with evidence collection governed under the Police and Criminal Evidence Act (PACE), 1984, ensuring proper chain of custody and forensic integrity.

3.2.2 Best Practices in Evidence Collection

The first responders to a crime scene, typically police officers and forensic investigators, must follow

¹⁶ **Daubert v Merrell Dow Pharmaceuticals, Inc**, 509 US 579 (1993).

¹⁷ **R v Doheny & Adams** [1997] 1 Cr App R 369.

a systematic approach to collecting evidence:

1. Crime Scene Securing & Documentation:

- o The crime scene must be sealed to prevent contamination.
- o Detailed photographs, sketches, and notes should be made before collecting any evidence.

2. Handling Physical Evidence:

- o Biological samples (blood, saliva, hair, etc.) must be collected using sterile tools and stored in tamper-proof containers.
- o Fingerprints should be lifted using dusting powder, chemical fuming, or advanced digital scanning techniques.
- o Ballistic evidence (bullets, shell casings, firearm residues) must be collected without altering markings that could be crucial for analysis.

3. Preservation of Digital Evidence:

- o Hard drives, mobile phones, and CCTV footage must be seized carefully to avoid data corruption.
- o A forensic image (clone) of digital devices should be created for examination.

4. Chain of Custody Maintenance:

- o Every piece of forensic evidence must be logged, labeled, and tracked from the crime scene to the courtroom.
- o A proper evidence custody log prevents unauthorized access and ensures accountability.

CHALLENGES IN EVIDENCE PRESERVATION

Despite established procedures, several challenges persist in the preservation of forensic evidence:

1. Risk of Contamination:

- o Improper handling of DNA, fingerprints, or biological fluids can render evidence unreliable.
- o In **Prakash v State of Karnataka**¹⁸, the Supreme Court rejected DNA evidence due to improper preservation.

2. Forensic Lab Backlogs:

¹⁸ **Prakash v State of Karnataka (2014) 12 SCC 133.**

- Many forensic labs in India, the U.S., and the U.K. face delays due to excessive caseloads and limited resources.
- This can lead to loss or degradation of crucial samples over time.

3. Technological Issues in Digital Evidence:

- Digital forensics is vulnerable to hacking, encryption challenges, and data corruption.

COMPARATIVE ANALYSIS OF SCIENTIFIC EVIDENCE IN CRIMINAL JUSTICE SYSTEMS – INDIA, U.S., AND U.K.

Forensic science has become an essential component of criminal justice systems worldwide. The use of DNA evidence, fingerprint analysis, ballistic tests, digital forensics, and toxicology reports helps law enforcement agencies identify offenders, reconstruct crime scenes, and ensure fair trials. However, the application and legal treatment of forensic evidence vary across different jurisdictions.

In India, forensic evidence is governed by the Bharatiya Sakshya Adhiniyam, 2023 (BSA) and other procedural laws, but challenges such as lack of infrastructure, expert bias, and improper evidence collection affect its reliability. In contrast, the United States follows the Daubert Standard to assess scientific validity, while the United Kingdom applies the Criminal Procedure Rules and case law precedents to regulate forensic testimony.

This chapter explores how forensic evidence is collected, analyzed, and admitted in courts across these three jurisdictions, highlighting similarities, differences, and best practices.

Legal Framework for Scientific Evidence in Criminal Justice Systems

The legal framework governing forensic evidence varies across India, the United States, and the United Kingdom, reflecting differences in their legal traditions and judicial approaches. While all three jurisdictions recognize the importance of scientific evidence in criminal trials, they have distinct standards for admissibility, reliability, and expert testimony.

India: Legal Provisions Governing Scientific Evidence

In India, forensic evidence is primarily regulated by the Bharatiya Sakshya Adhiniyam, 2023 (BSA), the Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS), and other procedural laws. The judiciary plays a significant role in shaping forensic evidence jurisprudence through landmark rulings.

1. Key Statutory Provisions

- **Expert Opinion**
 - Recognizes the role of forensic experts in criminal trials.
 - Courts rely on expert opinions for forensic analysis of fingerprints, handwriting, ballistics, toxicology, and DNA evidence.¹⁹
- **Electronic Evidence**
 - Establishes guidelines for admissibility of digital forensics, phone records, and computer-generated evidence.
 - Courts have ruled that electronic records must comply with Section 65B of the BSA for admissibility ²⁰.
- **Collection of Evidence**
 - Defines procedures for forensic evidence collection by police, ensuring that chain of custody is maintained.
 - Provides guidelines for forensic examination of rape victims, autopsy reports, and ballistic tests.

UNITED KINGDOM: FORENSIC EVIDENCE UNDER COMMON LAW

The U.K. follows a common law approach with strict forensic science regulations. Courts assess forensic evidence using legal precedents, expert guidelines, and procedural rules.

1. Criminal Procedure Rules (CPR, 2020)

- Requires forensic experts to provide objective and reliable testimony.
- Experts must disclose methodology, error rates, and statistical probability in their reports.

2. The Doheny & Adams Test (R v. Doheny & Adams, 1997)

- DNA evidence must be presented with statistical probabilities, ensuring courts understand the likelihood of matches.

¹⁹ RR Singh and others, 'Crime Scene to Courtroom: The Role of Forensic Experts' (2024) 6(1) *Journal of Criminology and Forensic Studies* 180068 <https://academicstrive.com/JOCFS/JOCFS180068.pdf> accessed 24 April 2025

²⁰ Bharat Vasani and Varun Kannan, 'Supreme Court on the Admissibility of Electronic Evidence under Section 65B of the Evidence Act' (27 January 2021) <https://corporate.cyrilamarchandblogs.com/2021/01/supreme-court-on-the-admissibility-of-electronic-evidence-under-section-65b-of-the-evidence-act/> accessed 24 April 2025

3. Forensic Science Regulator (FSR)

- Oversees forensic labs and expert witness standards.
- Ensures that forensic techniques meet reliability and accreditation standards.

4. Notable Cases

R v. T (2010) EWCA Crim 2439 – The court ruled that forensic evidence must not be presented in a misleading manner, emphasizing statistical reliability.²¹

CHALLENGES AND LIMITATIONS OF SCIENTIFIC EVIDENCE IN CRIMINAL JUSTICE

Scientific evidence plays a crucial role in modern criminal justice systems, but its use is not without challenges. While forensic science has significantly improved the accuracy of investigations, it also presents legal, technical, and ethical concerns. In India, issues such as poor forensic infrastructure, lack of trained personnel, procedural lapses, and judicial skepticism often hinder the effective use of scientific evidence.

Comparing India's forensic system with the U.S. and U.K. reveals key differences in admissibility standards, forensic regulation, and legal frameworks. Unlike these countries, India lacks a well-defined forensic evidence law and an independent forensic oversight body. This chapter examines the major challenges in the collection, analysis, and admissibility of forensic evidence and explores possible solutions to enhance its effectiveness in criminal trials.

Limitations in the Collection and Preservation of Scientific Evidence

Chain of Custody Issues

One of the primary concerns with forensic evidence in India is the lack of a strict chain of custody protocol. Chain of custody refers to the proper documentation and handling of forensic evidence to prevent tampering, loss, or contamination.

Key Issues:

²¹ **R v. T (2010) EWCA Crim 2439.**

- Many cases have been dismissed due to breaks in the chain of custody, raising doubts about the reliability of evidence.
- The lack of standardized procedures leads to improper collection and storage of evidence.
- Limited use of digital tracking systems results in misplacement or tampering of forensic samples.

Example: U.S. Approach

The U.S. follows strict chain of custody procedures, requiring digital tracking of evidence from collection to courtroom presentation.

Example: U.K. Approach

In the U.K., forensic evidence must meet the Forensic Science Regulator's Code of Practice to ensure proper chain of custody. India needs to adopt a national forensic evidence management system to ensure proper documentation and security of forensic samples.

Shortage of Accredited Forensic Laboratories

India faces a severe shortage of forensic laboratories, leading to delays in investigations and trials.

Key Issues:

- The lack of accredited forensic labs results in poor-quality forensic reports.
- Backlogs in forensic testing delay justice.
- State-run forensic labs face funding and staffing issues.

Example: U.S. and U.K. Forensic Labs

The U.S. has over 400 accredited forensic labs, ensuring timely forensic analysis. The U.K.'s Forensic Science Regulator ensures strict quality control in forensic laboratories. India must increase investment in forensic infrastructure and set up more accredited forensic labs to handle complex cases efficiently.

5.3 Issues with Forensic Expert Testimonies

5.3.1 Lack of Standardized Qualifications for Forensic Experts

Forensic expert testimony plays a key role in criminal trials, but India lacks clear guidelines on the qualification and accreditation of forensic experts.

Key Issues:

- Many forensic experts lack formal accreditation, leading to biased or unreliable testimony.
- Courts often rely on government forensic labs, which may be influenced by police or prosecution.
- Cross-examination of forensic experts is often weak, leading to misinterpretation of forensic findings.

Example: The U.S. Daubert Standard

The U.S. Daubert standard ensures that forensic expert testimony is based on scientific validity and peer-reviewed research.

Example: The U.K. Forensic Science Regulator

The U.K. requires forensic experts to follow strict codes of conduct, ensuring impartiality. India must introduce a certification system for forensic experts, ensuring that only qualified and independent experts testify in court.

5.4 Judicial Challenges in Evaluating Scientific Evidence

5.4.1 Judicial Skepticism Toward Forensic Evidence

Many Indian courts lack forensic training, leading to misinterpretation or rejection of forensic evidence.

Key Issues:

- Judges and lawyers lack scientific knowledge, leading to wrongful acquittals or convictions.
- Courts often reject forensic reports due to procedural errors in collection.
- Reliance on outdated forensic techniques, such as Narco-analysis, despite questionable scientific validity.

Example: The U.K. Judicial Training Board

The U.K. Judicial College provides forensic training to judges and lawyers. India must introduce forensic training programs for judges and legal practitioners to improve their ability to evaluate forensic evidence.

Technological and Ethical Concerns in Forensic Science

DNA Evidence and Privacy Issues

The rise of DNA databases has raised concerns over privacy rights and misuse of genetic data.

Key Issues:

- Lack of data protection laws for forensic databases in India.
- Risk of false matches in DNA profiling.
- Mass surveillance concerns due to unregulated biometric data collection.

Example: The U.K. Data Protection Act, 2018

The U.K. has strict laws on DNA data storage, ensuring privacy protection. India must enact clear regulations on forensic data collection and privacy to prevent misuse of genetic information.

Conclusion

The use of forensic science in criminal justice faces several challenges in India, including poor forensic infrastructure, lack of expert accreditation, weak procedural safeguards, and privacy concerns. Comparing India with the U.S. and U.K. highlights critical gaps in forensic standards, judicial training, and legal safeguards. To improve forensic reliability, India must adopt global best practices, ensure scientific accuracy in courtrooms, and introduce legal reforms that strengthen forensic governance.

References

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