RELEVANCE OF FORENSIC EVIDENCE AND ROLE OF TECHNOLOGY

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ABSTRACT

The modern science and technology has emerged as trouble shooter in the judicial system. The serious interface between technology and forensic science has also proved to lowering the evidentiary burden without any doubt. The state-of-the-art laboratories in the Universities and Forensic Science Institutions help in procurement of the evidences and help in use of modern equipment. After incorporation of new provisions in Bharatiya Sakshya Adhiniyam and Bharatiya Nagrik Suraksha Sanhita for admissibility of forensic evidences, there is a visible result of lowering pendency of cases in judiciary. Several times the Hon'ble Supreme Court in its judgments, the Central and State Government have been directed to develop the state of art infrastructure. The author discussed the judicial approach of biological and non-biological forensic evidence from case to case. To make it more full proof there is a dire need to develop the forensic science and technology infrastructure in the Universities and Forensic Science Laboratories/ Institutions. Hon'ble Supreme Court of India in Justice K.S. Puttaswamy case a 9-judge constitutional bench unanimously recognized the right to privacy as an intrinsic part of the Right to Life and Personal Liberty under *Article 21* of the Constitution, but still in criminal case legal burden lies on the prosecution while accused is presumed to be innocent.

Keywords: Forensic Science; Exoneration; Digital Records; Biological and Non-Biological.

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INTRODUCTION

The growing technology has emerged to be an important catalyst of the scientific findings and proved to be innovated in administration of justice in modern world. The modern science has helped the judicial system and society at large from complex new discoveries through technology. The serious interface between technology and forensic science, has proved to lower the evidentiary burden without any doubt. The state-of-the-art laboratories for Forensic science help in procurement of the evidences and help in use of modern equipment. This help in collection of the real-time, on-site of the forensic investigation. The new tools and technologies have strongly improved the speed and the efficacy of the administration of justice system. However, the results proved the fast closure, reliable and effective at all times for admissibility of the forensic evidence as in Bharatiya Sakshya Adhiniyam and Bharatiya Nagarik Suraksha Sanhita.

Forensic evidence enables to corroborate the relations between investigative hypotheses and objectives. This helps in proving or disapproving the connect between the evidence and crimes defined in the Indian legal system, while the Bharatiya Sakshya Adhiniyam, 2023 (BSA) which replaced the Indian Evidence Act, 1872 on July 1, 2024, modernizes how scientific and digital materials are procured and submitted into court.

OBJECTIVES OF FORENSIC EVIDENCE

The primary objective of forensic science is to apply scientific methods and principles to resolve legal matters, supporting a fair and unbiased criminal and civil justice system. There are some known objectives which includes:

(i)-Establish *Corpus Delicti*: To prove the Fact of the Crime (*Actus Reus*) which prove scientifically that a crime actually took place (e.g., determining the cause of death via forensic pathology or toxicology). The Forensic science uses physical, biological, or chemical findings (such as autopsy reports, ballistic matches, fire debris analysis, or toxicology) to demonstrate that a crime occurred rather than an accident, natural death, or suicide. It also supplies empirical proof independent of a suspect's confession. The legal standards mandate that a confession alone is insufficient without independent evidence showing the crime happened which shows independent verification. The forensic analysis also maps out how the offense unfolded, establishing the sequence of

events, tools used, and the nature of the damage or injury inflicted enables reconstruction of crime scene. It also help in homicide or missing-person cases where a physical corpse is not recovered, circumstantial and forensic proofs (such as bloodstain patterns, DNA, or digital records) can still establish that a death or crime took place, which help to overcome the absence of physical body. By demanding verifiable physical or scientific proof of the crime's occurrence, the corpus delicti rule prevents wrongful punishments stemming from coerced, fabricated, or false extrajudicial confessions. In cases like *Sevaka Perumal v. State of T.N.*[3], *Rama Nand v. State of Himachal Pradesh*[4], *Mani Kumar Thapa v. State of Sikkim* [5] and *Debojit Pankika v. State of Assam*[6], the Supreme Court established that the fact of death can be proved through reliable direct or circumstantial evidence even if the body is never found, provided the chain of circumstances points unerringly to the accused's guilt.

(ii)-Link Suspects and Scenes: Connect offenders, victims, and physical locations using biological traces (DNA), fingerprints, ballistics, and trace evidence (hair, fibers). Locard's Exchange Principle is The foundation of crime scene investigation holds that *"every contact leaves a trace",* meaning perpetrators leave something behind and take something with them. This is also known as Chain of Custody which is known as Proper collection, documentation, and laboratory transport are mandatory to ensure that physical proof remains uncontaminated before reaching court. As held by the Supreme Court of India in *Irfan @ Bhayu Mevati v. State of Madhya Pradesh* [7]**,** the court emphasized that relying on specialized scientific reports (such as DNA) requires proper examination and summoning of scientific experts in court to safeguard a fair trial. The courts also consistently rule that forensic reports (like Forensic Science Laboratory (FSL) or DNA data) must be backed by untainted chain-of-custody, proper sample collection, and corroborative circumstances rather than being accepted blindly as clinching proof.

(iii)- Corroborate Testimonies: Provide independent, tangible data to support or challenge human witness statements, which are otherwise vulnerable to memory decay

3 (1991) 3 SCC 471; 1991 AIR 1463 and 1991 SCR (2) 711.
4 (1981) 1 SCC 511; AIR 1981 SC 738 and [1981] 2 SCR 444.
5 (2002) 7 SCC 157; AIR 2002 SC 2920.
6 2026 INSC 687.
7 (2025) 16 SCC 357; [2025] 1 S.C.R. 1691 and 2025 INSC 150.

or bias. The Eyewitness memory can degrade or be influenced by stress. Forensic data—such as a DNA profile or a fingerprint—provides hard proof that places a specific person at the scene, backing up what a witness claims to have seen. The Supreme Court of India held in *Kannaiya v. State of Madhya Pradesh,*[8] **held that a conviction cannot be sustained if the genesis and manner of the incident in a criminal case cannot be corroborated beyond doubt. The Court exercised its powers under Article 142 to release convicts who were not parties to** the case.

(iv)- Exonerate the Innocent: Use objective scientific analysis to eliminate wrongful suspicion and protect individuals from miscarriages of justice. Forensic science does not only build convictions; it can also disprove false or mistaken testimonies by showing that physical traces do not match a witness's narrative, as held in Supreme Court of India in *Gambhir Singh v. State of UP,* [9] Reiterating the obligation of the prosecution to prove the guilt of the accused beyond reasonable doubt, the Supreme Court set aside the Appellant's conviction. The Appellant was convicted of murdering his brother, sister-in-law and their four children, allegedly over a land dispute. Most remedied wrongful convictions or acquittals in India happen through traditional appellate review, evaluation of witness credibility, or procedural lapses rather than formal post-conviction DNA testing or forensic audits.

(v)- Reconstruct Events: Establish the sequence, timing, and methodology of an incident through pattern analysis and physical impressions. It also help Analysts to interpret the shape, size, and distribution of blood drops to determine the position of the victim or attacker, the type of force used, and the direction of movement. By analyzing bullet holes, casing locations, and gunshot residue, experts map out shooting trajectories to figure out where a shooter stood and the sequence of shots fired. In landmark precedents such as *State v. Rodgers* (Supreme Court of Idaho)[10] and *State v. Hall* (Supreme Court of Iowa)[11], courts permitted BPA testimony based on the analyst's working knowledge of physics, math, and practical experience and the Supreme Court of India (*Kiran Raj* case)[12] set aside convictions and restored acquittals where Forensic

8 2025 INSC 1246 ; 2025 SCO.LR 10(4)[18].
9 2025 INSC 164 ; 2025 SCO.LR 7(2)[6].
10 144 Idaho 738, 170 P.3d 881 (2007).
11 287 N.W.2d 564 (Iowa 1980).
12 2025 LiveLaw (SC) 1231 ; 2025 INSC 1067.

Science Laboratory (FSL) Benzidine tests failed to detect blood on the accused's or victim's clothes despite prosecution claims. Metadata, cell tower pings, surveillance video, and computer logs help establish a strict chronological timeline of digital and physical movements. The Supreme Court of India ruled in May 2026 in *State of Tamil Nadu v. Ponnusamy*[13] that crime scene re-enactment does not violate the right against self-incrimination under Article 20(3) of the Constitution

ROLE OF BHARATIYA SAKSHIYA ADHINIYAM 2023:

(i)- The Bharatiya Sakshiya Adhiniyam 2023 updates evidence law to match modern technological advancements and works alongside companion statutes like the *Bharatiya Nagarik Suraksha Sanhita (BNSS), 2023;*

(ii) - **Expansion of Expert Opinions (Section 39 BSA)**: Replaces the older Section 45 of the Indian Evidence Act by broadening the scope of expert testimony to cover any specialized field, including digital forensics, cyber forensics, artificial intelligence, and specialized sciences. Expert testimony under Section 39 is advisory and is not binding on the court; the court must evaluate and weigh the evidence independently[14]. Section 39(1) of the BSA makes opinions of persons specially skilled in *any other field* relevant facts, rendering the provision open-ended to adapt to new scientific and technical domains. The Supreme Court emphasized that courts have the power and duty under Section 72 of the BSA to compare signatures or handwritings themselves[15]. Resorting to an expert is discretionary and should generally be exercised only when the court faces genuine doubt, or when the writing or impression is smudgy, vague, or very light.

(iii)- **Admissibility of Electronic and Digital Records (Sections 61–63 BSA)**: Modernizes rules for digital footprints, emails, server logs, and mobile data, carrying forward and refining certificate requirements (akin to former Section 65B) to ensure the integrity of electronic evidence. Section 61 of the Bharatiya Sakshya Adhiniyam, marks a clear shift toward treating electronic records as admissible evidence. It tells courts not to reject an electronic record just because it is digital whether it is an email, WhatsApp chat, CCTV footage, audio file or video file, or server log. The law

[13] 2026 INSC 507; 2026 (SC) 519 and 2026 SCO.LR 5(4)[18].
[14] Section 39, Bharatiya Sakshaya Adhiniyam 2023.
[15] Section 72, *ibid*.

recognises that modern communication and documentation often happen electronically, and such records can carry the same legal value as paper documents. At the same time, Sections 61 and 62 make it clear that this *"equal treatment"* is not automatic; admissibility and proof of contents must follow the safeguards as per section 63.[16] Section 63 provides the practical pathway for courts to accept electronic evidence without insisting on the original device every time. Under Section 63(1), a computer output such as a printout, CD or DVD copy, hard-disk copy, pen drive, memory card, or other copied form is treated as a document and can be admitted, provided the conditions in Section 63 are satisfied.[17] The Supreme Court clarified that certification under Section 63 is not restricted solely to government-notified Section 79A examiners; qualified individuals with demonstrated expertise in computer science and cyber forensics can also certify electronic records depending on the facts of the case. The Supreme Court rulings like *Anvar P.V. v. P.K. Basheer*[18] and *Arjun Panditrao Khotkar v. Kailash Kushanrao Gorantyal*[19], adapting them into the new criminal law framework active since July 1, 2024.

(iv)- **Redefinition of "Evidence" (Section 2 BSA / Definition)**: Explicitly incorporates electronic and digital records alongside oral and documentary statements to ensure courts treat digital material on par with physical documents;

(v)- **Integration with Mandatory Forensic Investigations (BNSS Section 176(3))**: While the BSA governs *admissibility*, related mandates under section 176(3) of BNSS makes the State Government to cause the forensic expert to visit the crime scene to collect forensic evidence in the offence and also cause videography of the process on mobile phone or any other electronic device where the crimes carrying a punishment of seven years or more, directly supplying the foundational material that the BSA admits into trials;

(vi)- **Chain of Custody and Verification**: All laboratories that have access to the evidence must maintain accurate accountability of the chain of custody. It is best for the laboratory to keep the evidence in safe, properly controlled storage facilities and to

[16] Section 61 & 62, The Bharatiya Sakshya Adhiniyam, 2023.
[17] Section 63, The Bharatiya Sakshya Adhiniyam, 2023.
[18] (2014) 10 SCC 473; AIR 2015 SC 180 and [2014] 11 S.C.R. 399.
[19] (2020) 7 SCC 1; (2020) 7 SCR 180.

limit the number of people who come in contact with the evidence.

Throughout the collection, handling, testing and storage procedures, strict protocols must be followed to ensure that the evidence remains verifiable in terms of authenticity and integrity. Each person that handles the evidence must be identified, and all periods of custody must be properly accounted for and recorded. This provides physical, biological, and digital facts that can link a suspect to a crime scene or decisively clear an innocent person.

The primary goal of forensic evidence is to provide scientific evidence of the crime scene that can withstand challenges in court. Therefore, all evidence must be carefully collected, preserved, analyzed, and documented to maintain its integrity which link a suspect to a victim. Bharatiya Sakshaya Adhiniyam Section 39 provides Expert opinions and scientific findings (DNA, ballistics, toxicology, trace evidence) are admitted under Section 39, but their legal weight depends heavily on proving an unbroken chain of custody-demonstrating that the item analyzed in the lab is the exact item seized at the crime scene without tampering.

BSA Section 63): Digital records, mobile data, cloud logs, and CCTV footage are treated as documents. To protect their integrity from alteration or deep-faking, Section 63 mandates verification through hash values (digital fingerprints) and a formal two-part certificate (Part A for technical/hash disclosures and Part B signed by a domain expert).

BNSS Section 176(3)): For offenses punishable by 7 years or more, the law makes a visit by a forensic expert to the crime scene compulsory to collect and package scientific evidence scientifically, reducing contamination risks

Forensic evidence is typically classified into two main categories:

- Biological Forensic Evidence
- Non-Biological Forensic Evidence

BIOLOGICAL FORENSIC EVIDENCE

Biological evidence refers to any type of evidence collected from a crime scene that originates from a living organism. This can include various bodily fluids, such as blood, saliva, and semen, as well as materials like hair, tissue, bones, and teeth. Each type of biological evidence

plays a crucial role in forensic investigations, as it can provide significant insights into the events surrounding a crime. The unique characteristics of biological evidence make it valuable for DNA analysis, which can help identify individuals involved in a case. The biological evidence will include any physical sample originating from a living organism-such as humans, animals, or plants-that can be analyzed to identify a person or establish a link to a crime scene and can therefore assist greatly in determining a person's identity. Biological evidence is often found in violent criminal activities such as murder, assault, sexual abuse, and kidnapping. The following are examples of types of biological evidence you might find:

(i) Blood-Blood is one of the most common types of biological evidence which includes Liquid blood, dried bloodstains, or blood mixed with clothing or weapons, used for blood typing and nuclear DNA profiling from white blood cells. As held in *State of Orissa v. Sahadeb*[20] The Supreme Court ruled that if a shirt or dhoti is recovered with blood stains proven to be human blood, but the serologist's report does not mention the blood group, it cannot be positively linked to the deceased. Small blood stains-especially on the clothes of villagers-may even be of the person's own blood. In case of *Rahul v. State of Delhi*[21] and *Irfan @ Bhayu Mevati v. State of Madhya Pradesh*[22], the Supreme Court set aside convictions where DNA profiling or serological reports suffered from custody lapses, unsealed transit, or failure to properly examine scientific experts.

(ii) Saliva- When evaluating the forensic nature of saliva for courtroom testimony, its availability as admissible evidence depends on the specific analytical form it takes. Saliva itself is a biological mixture of secretions, water, electrolytes, and shed epithelial cells. In legal proceedings, it is rarely introduced in its raw physical state; instead, it is admitted through structured scientific forms and presented via expert witness testimony. The Supreme Court of India in case of *Kattavellai@Devakar v. State of Tamil Nadu*[23], the Supreme Court issued strict guidelines for DNA evidence integrity, mandating proper collection documentation, trial court-authorized access, transport to a Forensic Science Laboratory (FSL) within 48 hours, and a maintained Chain of

[20] *[1987 AIR SC 1507].*
[21] (2023) 1 SCC 83; AIR 2022 SC 5661; 2023 CriLJ 1; 2022(4) RCR (Criminal) 993.
[22] (2025) 16 SCC 357; 2025 INSC 150.
[23] 2025 SCC OnLine SC 1439; 2025 INSC 845.

Custody of Register. *Manoj & Ors. v. State of Madhya Pradesh*[24], the Court noted that DNA samples collected from open areas or delayed in reaching the laboratory carry high risks of contamination and must be treated with caution and in case of *Selvi v. State of Karnataka*[25], the Supreme Court ruled that involuntary administration of narco-analysis, brain-mapping, and lie detector tests violates the right against self-incrimination (Article 20(3)) and personal liberty (Article 21).

(iii) Semen- Semen is most often used in sexual assault investigations to prove that sexual contact took place and can be used to identify the perpetrator via DNA testing. Biological evidence must be collected and preserved properly, as the biological material will deteriorate quickly. Forensic evidence of semen—such as vaginal/vulval swabs, seminal stains on clothing, and DNA profiling—serves as crucial corroborative proof in sexual assault and rape trials, though Indian courts treat it alongside primary testimonial evidence rather than as a standalone requirement. The Supreme Court of India has recognized DNA profiling as a highly scientific and reliable tool for criminal identification. In landmark rulings such as *Santosh Kumar Singh v. State through CBI*[26] and *Mukesh & Anr. v. State (NCT of Delhi) [Nirbhaya Case]*[27], the Court affirmed that DNA reports carry immense probative weight when biological evidence like semen, blood, or tissue is collected and matched properly. Courts have noted that semen can persist in the vaginal tract for a limited window (typically up to a few days), and the absence of semen or a delayed forensic sample does not automatically invalidate a victim's consistent and credible testimony, as seen in various Supreme Court and High Court evaluations in the case of *Mehtab v. State of Uttarakhand*[28].

(iv) Hair-In forensic science and legal proceedings, hair evidence is available for testimony in two distinct legal forms: class evidence and individual evidence**.** The Supreme Court of India (such as in *Mahmud v. State of UP*[29] has established that forensic evidence like hair or handwriting cannot be used as the sole basis for conviction without corroborating substantive evidence. However, the form it takes dictates how a forensic expert is legally permitted to testify about it in court. In the case

[24] (2023) 2 SCC 353; 2022 INSC 606.
[25] (2010) 7 SCC 263; AIR 2010 SC 1974.
[26] (2010) 9 SCC 747; (2010) 3 SCC (Cri) 1469 and 2010 SCC OnLine SC 1130.
[27] (2017) 6 SCC 1.
[28] 2026 INSC 578.
[29] (1976) 1 SCC 542.

of *Irfan @ Bhayu Mevati v. State of Madhya Pradesh*[30] the Supreme Court emphasized that DNA profiling matching hair and blood requires strict procedural integrity and the direct examination of DNA experts; failure to properly summon or examine scientific experts can vitiate a trial. In case of *Gura Singh v. State of Rajasthan*,[31] the Supreme Court evaluated Forensic Science Laboratory (FSL) reports where human head hair found on the weapon of offense (*kassi*) matched the hair of the deceased, treating it as reliable corroborative physical evidence linking the accused to the crime.

(v) Tissues and Skin Cells- During an altercation/scrap, several small tissue or skin cells may be found under the fingernails of one or both parties. These smaller biological samples can have DNA material and can assist in identifying the offender/suspect. The Court balances the state's need for biological evidence with an individual's right to privacy and dignity. In rulings like *Aparna Ajinkya Firodia v. Ajinkya Arun Firodia* and *CP v. AP*[32], the Court held that invasive scientific tests cannot be ordered routinely. To counter the high risk of contamination or degradation associated with touch DNA and minute skin flakes, the Supreme Court in *Kattavellai @ Devakar v. State of Tamil Nadu*[33] *(2025)* laid down mandatory guidelines for trial courts and law enforcement. In the landmark *Ranjitsing Brahmajeetsing Sharma v. State of Maharashtra*[34] is historically a landmark Supreme Court judgment regarding the interpretation of stringent statutory bail provisions under the *Maharashtra Control of Organised Crime Act (MCOCA* noted that cellular evidence must be evaluated in the context of the entire case to establish a prima facie conviction.

(vi) Bones and Teeth-Decomposed or burned bodies may provide a source of valuable forensic evidence through bones and teeth. Bones and teeth (including DNA extraction, forensic odontology/bite marks, and skeletal/ossification analysis) as corroborative proof under Section 45 of the Indian Evidence Act, now Section 39[35] of the BSA, rather than as sole or conclusive evidence. The Supreme Court upheld the credibility and scientific appreciation of forensic odontology. Photographs of bite marks on the victim were matched by experts with dental models of the accused, establishing a concrete link

[30] (2025) 16 SCC 357; 2025 INSC 150.
[31] (2001) 2 SCC 205; 2001 SCC (Cri) 323; [2000] Supp. 5 S.C.R. 408, and AIR 2001 SC 330.
[32] (2024) 7 SCC 773 ; 2023 INSC 146;
[33] (2025) SCC OnLine SC 1439; 2025 INSC 845
[34] (2005) 5 SCC 294; 2005 SCC (Cri) 1057).
[35] Section 39 of the Bharatiya Sakshya Adhiniyam, 2023.

that contributed to the conviction and death sentence as held in *Mukesh and Ors. v. State for NCT of Delhi & Ors.* / Nirbhaya Case, 2017.[36] The Supreme Court noted that bone ossification tests for age estimation cannot be treated as an exact science. Because of natural biological variations, a margin of error (typically of 1 to 2 years on either side) is factored in, making it supportive rather than decisive evidence as held in *Jaya Mala v. Home Secretary, Government of Jammu & Kashmir*.[37] In landmark trials involving decomposed, mutilated, or skeletonized remains (such as high-profile murder and "tandoor" style cases), the Supreme Court and trial courts have accepted DNA extracted from pulp tissue in teeth or bone marrow when matched with biological parents or relatives to confirm identity in case of *Sushil Sharma v. State (NCT of Delhi)*[38]

(vii) Urine and Other Biological Fluids-Urine, sweat, and vomit may also be used to provide toxicological evidence to help determine the consumption of drugs and/or alcohol. When biological fluids or DNA profiling are sought (such as in paternity or collateral criminal disputes), the Supreme Court mandates that courts cannot order forced biological sampling lightly; there must be a strong *prima facie* necessity, and it must balance fair trial rights against the fundamental right to privacy under Article 21[39]. The Supreme Court of India evaluates biological fluids (including blood, semen, saliva, and urine) and associated Forensic Science Laboratory (FSL) reports under Section 45 of the Indian Evidence Act, 1872 (now Section 39[40] of BSA as expert opinion evidence. In landmark rulings in *Irfan v. State of Madhya Pradesh*[41], the Supreme Court noted that convictions—especially those carrying severe punishments or death sentences—cannot safely rest on vague biological or forensic conclusions unless the scientific experts are properly summoned and examined under the law to explain their findings.

NON-BIOLOGICAL FORENSIC EVIDENCE

Non-biological forensic sciences focus on physical, chemical, digital, and mechanical evidence rather than living cells, DNA, or bodily fluids. These disciplines rely heavily on physics,

[36] (2017) 6 SCC 1; (2017) 2 SCC (Cri) 673; 2017 SCC Online SC 533.
[37] (1982) 2 SCC 538; 1982 SCC (Cri) 502.
[38] (2014) 4 SCC 317.
[39] Article 21 of the Constitution of India.
[40] Section 39, Bharatiya Sakshya Adhiniyam, 2023.
[41] 2025 INSC 150; [2025] 1 S.C.R. 1691.

mathematics, and analytical chemistry. The accuracy and admissibility of the evidence is totally dependent on the procedures and controls used.

(i) Reduction of Reliance on Hearsay: Minimizes the justice system's heavy dependence on fallible eyewitness testimonies, coerced statements, or subjective human memory. The Supreme Court has consistently held that hearsay evidence is generally inadmissible because it is derivative, second-hand, and lacks the accountability of cross-examination. In landmark rulings like *Parvat Singh*[42], the Supreme Court reiterated that statements recorded by investigating officers under Section 161 of the CrPC (now Section 180[43] of the BNSS) are inadmissible as primary evidence**.** They cannot form the sole basis of a conviction and can only be used to show contradictions. Hearsay evidence only becomes admissible under exceptions like *Res Gestae* (Section 6 of the BSA). However, in cases like *Sukhar v. State of U.P.*[44], the Supreme Court ruled that such spontaneous statements must be almost contemporaneous with the crime to eliminate any possibility of concoction or fabrication.

(ii) Legal Mandates: Modern legal frameworks (such as Section 176 of the Bharatiya Nagarik Suraksha Sanhita in India) increasingly mandate scientific and forensic investigation for serious offenses. The Supreme Court of India classifies forensic and scientific reports as advisory, corroborative opinion evidence rather than standalone proof of guilt, requiring strict compliance with constitutional safeguards and chain-of-custody rules. In landmark rulings such as *Magan Bihari Lal v. State of Punjab*[45] and *State of Himachal Pradesh v. Jai Lal*[46], the Supreme Court established that expert forensic opinion (such as handwriting, ballistic, or medical analysis) is an aid to the court and cannot be the sole basis for a conviction without independent supporting evidence. The Supreme Court held in *Selvi & Ors. v. State of Karnataka*[47] that the involuntary administration of lie-detector tests, narco-analysis, and brain-mapping violates Article 20(3)**[48]** (protection against self-incrimination) and infringes upon

[42] *Parvat Singh & Ors. v. State of Madhya Pradesh*, (2020) 4 SCC 33.
[43] Section 180 Bharatiya Nagarik Suraksha Sanhita, 2023.
[44] (1999) 9 SCC 507; AIR 1999 SC 3883, [1999] Supp 3 SCR 314, 2000 Cri LJ 29.
[45] (1977) 2 SCC 210; AIR 1977 SC 1091; [1977] 2 SCR 1007.
[46] (1999) 7 SCC 280; AIR 1999 SC 3318.
[47] (2010) 7 SCC 263; AIR 2010 SC 1974; [2010] 5 S.C.R. 381.
[48] Article 20(3), Constitution of India.

personal liberty and privacy under Article 21[49]**.** Such techniques are invalid unless performed with voluntary consent and judicial safeguards. As held in *Arjun Panditrao Khotkar v. Kailash Kushanrao Gorantyal*[50] the by the Supreme Court of India that For electronic and digital records, the Supreme Court ruled that a Section 65B[51] certificate (under the Indian Evidence Act / Bharatiya Sakshya Adhiniyam) is mandatory for admissibility, ensuring the integrity and provenance of the electronic device and output.

(iii) Cold Case Resolution: Allows re-examination of decades-old evidence using upgraded scientific techniques to bring closure to unsolved crimes. As evidence threshold, in cases involving delayed or historical prosecutions (such as long-pending murder or circumstantial cases), the Supreme Court frequently acquits accused persons if the prosecution relies solely on weak circumstantial links-such as the "last seen theory" without corroborating motive or recovered evidence.

ROLE OF TECHNOLOGY IN FORENSICS

(i) DNA & Biological Advancements: Next-generation sequencing (NGS), rapid DNA analysis (delivering results in hours), and touch DNA recovery allow matching of minuscule or degraded biological samples. Under Section 112[52] of the old Indian Evidence Act (and corresponding provisions in the Bharatiya Sakshya Adhiniyam, 2023), a child born during a valid marriage is legally presumed to be the legitimate child of that marriage. The Supreme Court of India balances scientific DNA evidence and biological advancements with fundamental constitutional rights—particularly the right to privacy under Article 21, recognized in *K.S. Puttaswamy v. Union of India*[53] and protections against bodily intrusion.

(ii) Digital and Cyber Forensics: Specialized software recovers deleted files, analyzes massive volumes of cloud or mobile data, and tracks cybercrimes, financial fraud, and digital communications. In October 2026, a Supreme Court bench termed organized cybercrime and "digital arrests" as digital dacoity, refusing to consolidate multiple state criminal complaints against account mules and prioritizing the integrity of cross-

[49] Article 21, Constitution of India.
[50] (2020) 7 SCC 1; [2020] 7 S.C.R. 180; AIR 2020 SC 4908.
[51] Section 65B, Bharatiya Sakshya Adhiniyam 2023.
[52] Section 116, *Ibid.*
[53] (2017) 10 SCC 1; AIR 2017 SC 4161; (2019) 1 SCC 1.

country police investigations over the convenience of the accused. Reserve Bank of India to evaluate mandating financial institutions to fully compensate digital arrest and cyber-fraud victims if the crime occurred due to a lack of proper institutional due diligence. In landmark rulings such as *Anvar P.V. v. P.K. Basheer*[54] and subsequent interpretations in *Arjun Khotkar*[55], the Supreme Court mandated that secondary electronic records require a proper certificate under Section 65B to be legally admissible. Recent clarifications have further confirmed that qualified cyber forensic and computer science experts are competent to sign these authenticity certificates.

(iii) Biometrics and Automated Systems: Automated Fingerprint Identification Systems (AFIS), facial recognition, iris scans, and voice biometrics match trace markers against large databases in seconds. In *Justice K.S. Puttaswamy v. Union of India*[56]**,** 2018), a Constitution Bench upheld the Aadhaar Act (2016) for welfare distributions but restricted private-sector mandatory usage, limited data storage periods, and struck down provisions risking mass surveillance. In *Pragya Prasun v. Union of India*[57], The Court ruled that rigid biometric and facial recognition authentication protocols violate Articles 14, 15, and 21[58] when they exclude disabled, elderly, or manual-laborer citizens, ordering KYC standard revisions and offline alternatives. The Supreme Court (headed by Chief Justice Surya Kant) issued notices to the Centre and the Election Commission on a Public Interest Litigation (PIL) seeking fingerprint and iris-based biometric identification at polling stations to prevent proxy and duplicate voting.

(iv) Non-Invasive Autopsies *("Virtopsy"):* AI-enhanced 3D imaging, CT scans, and MRI scans map internal trauma and causes of death without traditional invasive procedures. Courts evaluate virtual autopsy reports under Sections 45–46 of the Indian Evidence Act (and corresponding Section(s) 39 and 40[59] in the Bharatiya Sakshya Adhiniyam, 2023, requiring that scientific and digital findings rely on recognized methodologies and certified expert interpretation, as previously established in

[54] (2014) 10 SCC 473; [2014] 11 S.C.R 399; AIR 2015 SC 180.
[55] (2020) 7 SCC 1; [2020] 7 S.C.R. 180; AIR 2020 SC 4908.
[56] 2019(1)SCC 1 and AIR 2018 SC(SUPP)1841.
[57] [2025] INSC 599; 2025 SCC OnLine SC 993.
[58] Article(s) 14, 15 and 21 of the Constitution of India.
[59] Section(s) 39 and 40, Bharatiya Sakshya Adhiniyam, 2023.

precedents like *Ramesh Chandra Agrawal v. Regency Hospital Ltd*[60].

(v) Trace and Chemical Analysis: Tools like laser ablation (LA-ICP-MS) and gas chromatography-mass spectrometry (GC-MS) evaluate microscopic fibers, ballistics, and chemical residues with high fidelity. Trace and chemical analysis reports (such as forensic chemistry, toxicology, viscera reports, and contraband/drug analysis) are treated by the Supreme Court of India and high courts as crucial scientific opinion evidence, subject to strict statutory rules and evidentiary safeguards. Trace and chemical analysis findings fall under expert testimony provisions (historically Section 45 of the Indian Evidence Act, 1872, and corresponding provisions under the Section 39[61] of Bharatiya Sakshya Adhiniyam, 2023. Section 39(1) of the BSA re-enacts Section 45 while expanding the scope to include "or any other field" (beyond just science or art), and Section 39(2) incorporates the provisions of the old Section 45A regarding the Examiner of Electronic Evidence. The Supreme Court in *State of Himachal Pradesh v. Jai Lal*[62] has cautioned that chemical or forensic opinions are intended to *aid* the judge in evaluating facts rather than replacing judicial evaluation. They must be corroborated by surrounding circumstantial or direct evidence.

KEY CHALLENGES AND LIMITATIONS

(i) Risk of Contamination and Error: Mishandling chains of custody, improper field collection by non-specialists, or subjective interpretation can compromise results. In forensic science, the Supreme Court has emphasized that while DNA evidence is highly reliable, its legal validity is strictly dependent on protecting the sample from the risk of contamination and human error during collection and processing. In milestone rulings like *Kattavellai @ Devakar v. State of Tamil Nadu*[63], the Court noted that when forensic samples are handled without strict adherence to standard scientific protocols, the risk of contamination spikes. In the landmark 2026 suo motu case *In Re: 2 Million Lives at Risk, Contamination in Jojari River, Rajasthan*[64], the Supreme Court clamped down on regulatory bodies and state governments for allowing decades of unchecked industrial effluents and sewage to discharge into public river networks. In landmark challenges

[60] 2009) 9 SCC 709; (2009) 3 SCC (Civ) 840).
[61] Section 39 of Bharatiya Sakshya Adhiniyam, 2023.
[62] (1999) 7 SCC 280; *AIR 1999 SC 3318*; *1999 Supp (2) SCR 318*.
[63] 2025 SCC OnLine SC 1439; 2025 SCC OnLine SC 1439; 2025 INSC 845.
[64] 2025 SCC OnLine SC 2518; 2025 INSC 1341; 2026 INSC 316 and 2026 INSC 812.

surrounding GM crops (such as *Gene Campaign v. Union of India*[65], the Court evaluated petitions warning that the open-field testing of herbicide-tolerant (HT) or genetically modified seeds posed an irreversible risk of contaminating native gene banks and adjacent organic fields. On the counter-point of regulatory "error", the Supreme Court has re-established that in complex economic or scientific matters, the Government has a bona fide right to *"trial and error"* as long as it operates within constitutional limits. However, when an error presents an irreversible risk of environmental contamination, the judiciary uses the *Precautionary Principle* to halt activities until safety is strictly proven.

(ii) Data Privacy and Ethics: Surveillance tools, facial recognition, and genetic mapping raise significant civil liberties and data protection concerns. In *Justice K.S. Puttaswamy (Retd.) v. Union of India*[66], a 9-judge constitutional bench unanimously recognized the right to privacy as an intrinsic part of the Right to Life and Personal Liberty under Article 21 of the Constitution.

(iii) Infrastructure Gaps: Uneven regional distribution of advanced forensic labs can delay trials and strain investigative pipelines. Due to the forensic laboratories across India face massive case backlogs ranging from 18,000 to over 62,000 pending cases per facility, delaying trials and straining the right to a speedy trial under Article 21. *Selvi v. State of Karnataka*[67], the Supreme Court restricted the involuntary use of specialized forensic tools (such as narco-analysis, polygraph, and brain mapping), ruling that forced testing violates Article 20(3) (self-incrimination) and Article 21 (mental privacy). Furthermore, cases like *Mahmud v. State of UP*[68] established that forensic opinions cannot stand as the sole basis for a conviction without proper expert testimony and corroboration.

CONCLUSION

Forensic evidence enables to corroborate the relations between investigative hypotheses in proving or disapproving with the help of forensic evidences in crimes. Forensic Science scientifically intervene the connect with the crime scene which includes biological or non-

[65] 2024 SCC OnLine SC 1793; 2024 INSC 545
[66] (2017) 10 SCC 1; AIR 2017 SC (Civ) 2714; [2017] 10 S.C.R. 569.
[67] (2010) 7 SCC 263; AIR 2010 SC 1974; [2010] 5 S.C.R. 381.
[68] (1976) 1 SCC 542; AIR 1976 SC 69; 1976 Cri LJ 10; 1975 (7) UJ 875 (SC).

biological substances. The forensic analysis also maps out how the offense unfolded, establishing the sequence of events, tools used, and the nature of the damage or injury inflicted enables reconstruction of crime scene. **The Court exercised its powers under Article 142 to release convicts who were not parties to** the case based on the cases to cases at various time. Most remedied wrongful convictions or acquittals in India happen through traditional appellate review, evaluation of witness credibility, or procedural lapses rather than formal post-conviction DNA testing or forensic audits. Section 63 of Bharatiya Sakshaya Adhiniyam provides the practical pathway for courts to accept electronic evidence without insisting on the original device every time. The Supreme Court clarified that certification under Section 63 is not restricted solely to government-notified Section 79A examiners; qualified individuals with demonstrated expertise in computer science and cyber forensics can also certify electronic records depending on the facts of the case. The Supreme Court rulings like *Anvar P.V. v. P.K. Basheer* and *Arjun Panditrao Khotkar v. Kailash Kushanrao Gorantyal.* Physical, biological, and digital facts that can link a suspect to a crime scene or decisively clear an innocent person. As evidence threshold, in cases involving delayed or historical prosecutions, the Supreme Court frequently acquits accused persons if the prosecution relies solely on weak circumstantial links without corroborating motive or recovered evidence. The Supreme Court clamped down on regulatory bodies and state governments for allowing decades of unchecked industrial effluents and sewage to discharge into public river networks and the Government has a bona fide right to *"trial and error"* as long as it operates within constitutional limits due to which India face massive case backlogs due to Uneven regional distribution of advanced forensic labs can delay trials and strain investigative pipelines. The right to privacy as an intrinsic part of the Right to Life and Personal Liberty under Article 21 of the Constitution. Therefore, government must focus on the establishing the reliable forensic laboratories and institutions.