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From Scientific Validity to Judicial Admissibility: Rethinking the Legal Regulation of Forensic Evidence

YOGESH CHANDRA GUPTA* AND DR. ARSHAD HUSSAIN**

ABSTRACT

The role of forensic evidence in criminal decision-making is growing, yet the interaction between law and forensic science remains uneasy. Fingerprint evidence, DNA profiles, the statements of ballistics experts, narcoanalysis and other 'scientific' tests of behaviour are routinely introduced in court, and their probative value is assumed because they are based on science. This paper critiques the conceptual grey area between two distinct categories: an empirical attribute, scientific validity, determined by testing, peer review, known error rates and methodological rigour; and a legal attribute, judicial admissibility, governed by far more permissive criteria such as general acceptance and expert competence. Drawing on the Frye *and* Daubert *decisions in the United States, the reliability-based approach now followed in England and Wales, and the less developed position of Indian courts under the Indian Evidence Act, 1872 and the Bharatiya Sakshya Adhiniyam, 2023, in force since 1 July 2024, the paper argues that Indian courts have not yet formed a coherent methodology for evaluating forensic evidence. It examines DNA profiling, narcoanalysis, and fingerprint and bite-mark identification as illustrations of this gap and, drawing on the recommendations of the National Research Council and the PCAST Report, recommends a statutory reliability threshold together with a validation and accreditation process to reconcile what science can prove with what courts can accept.*

Keywords: *Forensic evidence, scientific validity, Daubert standard, judicial admissibility of evidence*

I. INTRODUCTION

In many criminal trials forensic science is the hidden adjudicator. Whether a fingerprint is lifted from a windowpane, a bloodstain is matched to a DNA profile, or a voice sample is compared through spectrographic analysis, the findings of such tests can establish guilt or innocence in a way that an eyewitness rarely can.[1] The apparent objectivity of forensic techniques, with their vocabulary of probabilities, matches and exclusions, lends them a persuasive force before

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[1] ANDRE A. MOENSSENS ET AL., SCIENTIFIC EVIDENCE IN CIVIL AND CRIMINAL CASES 1–3 (5th ed. 2007).

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judges and juries alike that is often disproportionate to their actual epistemic reliability. Yet the assumption that a technique is "scientific" and therefore admissible conflates two distinct inquiries: whether a method is scientifically valid, in the sense that it has undergone rigorous testing and peer evaluation and has been shown to produce results within a known and acceptable error rate; and whether it is judicially admissible, a status conferred by rules of evidence that were, for most of legal history, indifferent to these empirical questions.[2]

The distinction is not merely academic. In its 2009 report *Strengthening Forensic Science in the United States*, the U.S. National Research Council concluded that, with the exception of nuclear DNA analysis, no forensic method had been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source.[3] Seven years later, the President's Council of Advisors on Science and Technology (PCAST) reached a similarly unsettling conclusion in respect of feature-comparison disciplines such as bite-mark, firearms and footwear analysis.[4] These findings have unsettled the assumption, long embedded in adversarial trial practice, that forensic evidence which has "always" been admitted must therefore be reliable.

India offers an even more pronounced illustration of the problem. The Indian Evidence Act, 1872, drafted before the emergence of DNA typing, digital forensics or neuroscientific lie detection, contains no general test of scientific reliability. Sections 45 to 51, which govern the opinions of third persons, including experts, ask only whether a witness possesses special skill in a particular science or art; they do not ask whether the science itself has been validated.[5] Consequently, Indian courts have historically approached forensic evidence through an admissibility lens borrowed from the law of expert testimony, rather than through any independent assessment of scientific soundness. This paper examines that gap and argues for its closure through statutory and institutional reform. Its method is doctrinal and comparative: it reads the Indian statutory framework and the leading decisions of the Supreme Court against the admissibility standards of the United States and of England and Wales, and against the scientific assessments of the National Research Council and PCAST. Electronic records, which

[2] Paul C. Giannelli, *The Admissibility of Novel Scientific Evidence: Frye v. United States, a Half-Century Later*, 80 COLUM. L. REV. 1197, 1200 (1980), https://scholarlycommons.law.case.edu/faculty_publications/1109.

[3] NATIONAL RESEARCH COUNCIL, STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD 7–8 (2009), https://doi.org/10.17226/12589.

[4] PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY, EXECUTIVE OFFICE OF THE PRESIDENT, REPORT TO THE PRESIDENT: FORENSIC SCIENCE IN CRIMINAL COURTS: ENSURING SCIENTIFIC VALIDITY OF FEATURE-COMPARISON METHODS 1–4 (2016) [hereinafter PCAST Report], https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_forensic_science_report_final.pdf.

[5] The Indian Evidence Act, No. 1 of 1872, INDIA CODE (1872), §§ 45–51.

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are governed by the distinct certification regime of Section 63 of the Bharatiya Sakshya Adhiniyam, 2023, the successor to Section 65B of the Evidence Act, fall outside its scope.[6]

II. SCIENTIFIC VALIDITY: MEANING AND STANDARDS

Scientific validity is not a single, static attribute; it exists on a continuum and is discipline-specific. In the framework articulated by PCAST, a method is foundationally valid when it has been shown, through repeatable and independently reproducible empirical studies, to be capable of producing accurate results, and when its error rate is known and acceptably low.[7] It is valid as applied when an examiner, using the foundationally valid method with appropriate skill, reaches a conclusion supported by the available data in a given case. The distinction is critical because a scientifically sound technique may still yield an unreliable result if performed carelessly, and a poorly validated technique may occasionally produce a correct answer by chance.

Nuclear DNA analysis is often described as the paradigm of a foundationally valid forensic technique: it rests on sound principles of population genetics, its error rates have been extensively studied, and its results are expressed in statistically quantifiable form.[8] By contrast, disciplines based on subjective pattern-matching, such as latent fingerprint comparison, bite-mark analysis, handwriting identification, and firearm and toolmark comparison, have never had the same empirical basis. Examiners in these disciplines have traditionally testified to absolute "matches", and the absence of a documented error rate and of a statistical basis for such conclusions has been questioned with increasing force.[9] These disciplines are not, however, equally weak. PCAST found latent fingerprint analysis to be foundationally valid, but with a substantial false-positive rate, one that could be as high as 1 in 306 in one study and 1 in 18 in another, and likely to be higher than many jurors would expect. It found that firearms analysis still fell short of the scientific criteria for foundational validity, and that bite-mark analysis was far from meeting them.[10]

In short, "forensic science" is not a single, uniform category for the purposes of admission. A law that assigns the same weight to DNA profiling and to bite-mark comparison fails to reflect this internal heterogeneity, and it is precisely such subjective comparisons, presented as "scientific", that have contributed to miscarriages of justice.

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[6] Indian Evidence Act § 65B; The Bharatiya Sakshya Adhiniyam, No. 47 of 2023, INDIA CODE (2023), § 63; *Arjun Panditrao Khotkar v. Kailash Kushanrao Gorantyal*, (2020) 7 SCC 1 (India).
[7] PCAST Report, *supra* note 4, at 4–5, 47–48.
[8] National Research Council, *supra* note 3, at 130–33.
[9] PCAST Report, *supra* note 4, at 46–50.
[10] *Id.* at 8–11.

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III. Admissibility frameworks: a comparative study

A. The *Frye* "general acceptance" test

The first organised attempt in the United States to regulate the admissibility of novel scientific evidence was *Frye v. United States*, in which the Court of Appeals of the District of Columbia rejected evidence of a systolic blood pressure deception test, a precursor of the modern polygraph, because the method had not become "sufficiently established to have gained general acceptance in the particular field in which it belongs".[11] The *Frye* test thus outsourced the reliability inquiry to the relevant community of experts: courts did not themselves evaluate a method's validity but asked only whether that community had already done so and reached a consensus. The test's principal virtue was its deference to scientific expertise and its corresponding restraint on judicial overreach into technical matters; its principal vice was that "general acceptance" could lag well behind, or occasionally run ahead of, genuine empirical validation, and that novel but sound techniques could be excluded merely for want of a mature professional constituency.[12]

B. The *Daubert* trilogy and judicial gatekeeping

In *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, the Supreme Court of the United States held that the *Frye* standard had been superseded in the federal courts by the Federal Rules of Evidence. Under Rule 702, the Court said, the trial judge must ensure that any scientific testimony admitted is not only relevant but reliable, that is, grounded in scientifically valid reasoning and methodology. To that end the Court offered a set of flexible factors to guide the inquiry: whether the theory or technique can be, and has been, tested; whether it has been subjected to peer review and publication; its known or potential rate of error and the existence of standards controlling its operation; and whether it is generally accepted within the relevant scientific community.[13] The United States is not, however, uniform on the point: several states, including California, New York and Illinois, have retained the *Frye* standard.[14]

In *General Electric Co. v. Joiner*, the Supreme Court held that appellate courts review a trial court's gatekeeping decision for abuse of discretion, giving trial judges considerable latitude at first instance.[15] *Kumho Tire Co. v. Carmichael* extended the *Daubert* gatekeeping obligation

[11] *Frye v. United States*, 293 F. 1013, 1014 (D.C. Cir. 1923).
[12] Giannelli, *supra* note 2, at 1205–08.
[13] *Daubert v. Merrell Dow Pharms., Inc.*, 509 U.S. 579, 593–94 (1993).
[14] *People v. Kelly*, 549 P.2d 1240 (Cal. 1976); *People v. Leahy*, 882 P.2d 321 (Cal. 1994) (reaffirming the *Kelly* test after *Daubert*); *People v. Wesley*, 633 N.E.2d 451 (N.Y. 1994); *Donaldson v. Cent. Ill. Pub. Serv. Co.*, 767 N.E.2d 314 (Ill. 2002).
[15] *Gen. Elec. Co. v. Joiner*, 522 U.S. 136, 138–39, 141–43 (1997), https://supreme.justia.com/cases/federal/us/522/136/.

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beyond scientific testimony to all expert testimony based on technical or other specialised knowledge, closing a gap that might otherwise have allowed non-scientific expertise to escape scrutiny.[16] Rule 702 was amended in 2000 to codify these decisions and again with effect from 1 December 2023. The 2023 amendment makes explicit that the proponent must demonstrate to the court that it is more likely than not that the testimony is based on sufficient facts or data, is the product of reliable principles and methods, and reflects a reliable application of those methods to the facts of the case.[17]

The *Daubert* framework marks a shift from consensus to methodology: a court applying *Daubert* does not ask what the scientific community thinks, but whether the method itself bears the indicia of empirical soundness. Critics have noted that trial judges are frequently ill-equipped to perform this function, lacking scientific training and often relying on the very adversarial experts whose testimony is under scrutiny. Studies of the case law in the years after *Daubert* found that the gatekeeping factors were applied inconsistently and sometimes cursorily, particularly in criminal as opposed to civil proceedings, where defence challenges to prosecution experts have rarely succeeded.[18]

C. The reliability approach in England and Wales

England and Wales offer a further common law model, and one that is arguably more instructive for India. In 2011 the Law Commission concluded that expert opinion evidence was being admitted in criminal proceedings too readily, with insufficient scrutiny, and recommended a statutory test under which such evidence would be admissible only if it was sufficiently reliable.[19] Although Parliament did not enact the recommended provision, its substance has been adopted through the Criminal Practice Directions, which now require the court to be satisfied that expert opinion is sufficiently reliable to be admitted and list the factors relevant to that determination, among them the extent and quality of the data on which the opinion is based, the validity of the methodology employed, the degree of precision or margin of uncertainty affecting the results, and the extent to which the underlying material has been reviewed by others with relevant expertise.[20] The English experience shows that a reliability threshold can

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[16] *Kumho Tire Co. v. Carmichael*, 526 U.S. 137, 147–49 (1999), https://supreme.justia.com/cases/federal/us/526/137/.

[17] Fed. R. Evid. 702 (as amended Dec. 1, 2023), https://www.law.cornell.edu/rules/fre/rule_702.

[18] D. Michael Risinger, *Navigating Expert Reliability: Are Criminal Standards of Certainty Being Left on the Dock?*, 64 ALB. L. REV. 99 (2000), https://papers.ssrn.com/abstract=251033; Jane Campbell Moriarty, *Will History Be Servitude?: The NAS Report on Forensic Science and the Role of the Judiciary*, 2010 UTAH L. REV. 299, https://dc.law.utah.edu/ulr/vol2010/iss2/5/.

[19] LAW COMMISSION, EXPERT EVIDENCE IN CRIMINAL PROCEEDINGS IN ENGLAND AND WALES paras 1.2, 1.17 (Law Com No. 325, HC 829, 2011) (UK), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/229043/0829.pdf.

[20] Criminal Practice Directions 2023, paras 7.1.1–7.1.3 (Eng. & Wales).

be introduced into an adversarial common law system through rules of court as well as through primary legislation, a point of direct relevance to Indian reform.

D. The Indian position under the Evidence Act

Indian law has no developed gatekeeping doctrine. Section 45 of the Indian Evidence Act, 1872 makes relevant the opinions of persons "specially skilled" in foreign law, science or art, or in questions as to the identity of handwriting or finger impressions, but the provision addresses only the competence of the witness, not the validity of the discipline itself.[21] The Supreme Court has repeatedly stressed that expert evidence is advisory rather than conclusive, and that the court must still form its own independent judgment on the weight it deserves.[22] In *Ramesh Chandra Agrawal v. Regency Hospital Ltd.*, the Court went a step further and held that expert evidence is admissible only where the expert is within a recognised field of expertise, the evidence is based on reliable principles, and the expert is qualified in that discipline.[23] These criteria resemble the *Daubert* factors in outline but have not evolved into a structured inquiry into admissibility. In practice, this formal caution has usually yielded a loose inquiry focused on whether the witness has the necessary credentials and experience, without the analytical machinery of *Daubert*.

The Bharatiya Sakshya Adhiniyam, 2023, which replaces the Evidence Act, reproduces the provision on expert opinion in substantially the same form; indeed, Section 39(1) widens it by extending expert opinion to "any other field" without adding any criterion of reliability, so that the conceptual lacuna identified in this paper survives, and is arguably enlarged by, the recent codification.[24] The criminal procedure codes compound the difficulty. Section 293 of the Code of Criminal Procedure, 1973, now Section 329 of the Bharatiya Nagarik Suraksha Sanhita, 2023, allows the report of a designated Government scientific expert to be used as evidence without the expert being examined, unless the court thinks fit to summon the expert; a forensic report can thus enter the record without any oral testing of its method.[25] At the same time, Section 176(3) of the Sanhita requires that, from a date to be notified by the State Government within five years, a forensic expert visit the crime scene to collect forensic evidence in every offence punishable with imprisonment for seven years or more, while Section 349 extends the Magistrate's power to order specimen signatures and handwriting to finger impressions and

[21] Indian Evidence Act § 45.
[22] *State of Himachal Pradesh v. Jai Lal*, (1999) 7 SCC 280, para 18, AIR 1999 SC 3318, 3322 (India).
[23] *Ramesh Chandra Agrawal v. Regency Hospital Ltd.*, (2009) 9 SCC 709, para 11 (India).
[24] Bharatiya Sakshya Adhiniyam § 39(1); *cf.* Indian Evidence Act § 45.
[25] The Code of Criminal Procedure, No. 2 of 1974, INDIA CODE (1974), § 293; The Bharatiya Nagarik Suraksha Sanhita, No. 46 of 2023, INDIA CODE (2023), § 329.

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voice samples, building on *Ritesh Sinha v. State of Uttar Pradesh*.[26] Read with the Criminal Procedure (Identification) Act, 2022, which authorises the collection of finger impressions, iris and retina scans and biological samples, these provisions will multiply the volume of forensic material reaching the courts.[27] Yet neither the Code of Criminal Procedure nor the Sanhita supplies a structural mechanism, such as a pre-trial admissibility hearing dedicated to scientific evidence, through which the validity of a forensic technique could be tested before it reaches the trier of fact. The result is that novel or contested forensic methods are typically admitted as a matter of course, with their reliability left to be tested, if at all, through cross-examination at trial, a mechanism poorly suited to exposing methodological flaws that both prosecution and defence counsel may lack the scientific literacy to identify.[28]

IV. THE GAP BETWEEN VALIDITY AND ADMISSIBILITY

The preceding comparison reveals a structural gap that exists, in different degrees, in every jurisdiction examined, but is most pronounced in India. Even the *Daubert* framework, for all its analytical sophistication, ultimately entrusts the validity determination to individual trial judges operating within an adversarial system that rewards persuasion over precision. The Indian system does not go even that far: because no statutory standard of reliability requires validation, admissibility depends almost entirely on the formal qualifications of the witness rather than on whether the technique has been scientifically tested.

The gap is evident in at least three ways. First, there is definitional slippage: "expert evidence" is often conflated with "scientific evidence", so that the testimony of a witness who is genuinely expert in a practice whose validity has never been scientifically studied, such as traditional fingerprint examination, is treated as if it were scientific evidence.[29] Second, there is an imbalance of resources: prosecutors usually have access to state-funded forensic laboratories, whereas indigent defendants often have no comparable facility for independent forensic review, so that both *Frye* and *Daubert* presuppose a degree of adversarial testing that is not always performed in practice.[30] Third, there is a temporal mismatch: forensic techniques are sometimes introduced into the courtroom when they are professionally fashionable but not yet scientifically

[26] Bharatiya Nagarik Suraksha Sanhita §§ 176(3), 349; *Ritesh Sinha v. State of Uttar Pradesh*, (2019) 8 SCC 1 (India).
[27] The Criminal Procedure (Identification) Act, No. 11 of 2022, INDIA CODE (2022), §§ 2(1)(b), 3.
[28] National Research Council, *supra* note 3, at 12.
[29] Simon A. Cole, *Grandfathering Evidence: Fingerprint Admissibility Rulings from Jennings to Llera Plaza and Back Again*, 41 AM. CRIM. L. REV. 1189, 1193–95 (2004).
[30] Paul C. Giannelli, *Ake v. Oklahoma: The Right to Expert Assistance in a Post-Daubert, Post-DNA World*, 89 CORNELL L. REV. 1305 (2004), https://scholarship.law.cornell.edu/clr/vol89/iss6/1.

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mature, and, once introduced, they persist in courtroom practice even after being empirically discredited, owing to precedent and judicial deference to "established practice".[31]

V. Case studies in the Indian context

A. DNA profiling

The use of DNA evidence demonstrates both the promise of forensic science in Indian courts and the risks of mishandling it. In *Santosh Kumar Singh v. State through CBI*, the Supreme Court relied on DNA profiling as cogent evidence of rape and of the identity of the offender, accepting the DNA report as scientifically accurate and declining to substitute its own view for that of the experts on a highly technical subject, particularly as the questions raised by the trial court had not been put to the expert witnesses.[32] In *Krishan Kumar Malik v. State of Haryana*, by contrast, no DNA test had been conducted at all; the Court treated the omission as a serious lapse, observing that after the insertion of Section 53A into the Code of Criminal Procedure in 2006 it had become necessary for the prosecution to go in for DNA testing in such cases, and acquitted the accused.[33] More recent decisions show the Court beginning to scrutinise the applied validity of DNA results. In *Manoj v. State of Madhya Pradesh*, the Court held that the DNA report could not carry clinching or high probative value: the recoveries on which it depended were suspect, the expert had not explained the probability of a random match, and contamination could not be ruled out; the appellants had also pointed to an unexplained delay of twenty days in sending the seized articles to the laboratory, the lack of statistical analysis, and the absence from the record of the analyst's observation sheet.[34] In *Rahul v. State of Delhi*, the Court criticised the courts below for examining neither the underlying basis of the DNA reports nor whether the techniques had been reliably applied, pointing out that the samples had remained in the police *malkhana* for more than ten days before they were sent to the laboratory.[35] Most recently, in *Kattavellai v. State of Tamil Nadu*, the Court issued general directions requiring documented collection of DNA samples, their dispatch to the forensic science laboratory within 48 hours of collection, and a chain-of-custody register to be appended

[31] Cole, *supra* note 29, at 1230–33.
[32] *Santosh Kumar Singh v. State through CBI*, (2010) 9 SCC 747, para 51 (India).
[33] *Krishan Kumar Malik v. State of Haryana*, (2011) 7 SCC 130, 140, para 44 (India).
[34] *Manoj v. State of Madhya Pradesh*, (2023) 2 SCC 353 (India) (Criminal Appeal Nos. 248–250 of 2015, decided May 20, 2022), paras 133, 142–43 (paragraph numbers as in the judgment text at the URL cited, not the SCC report), https://lawrato.com/supreme-court-judgements/criminal/manoj-vs-the-state-of-madhya-pradesh-174.
[35] *Rahul v. State of Delhi*, 2022 INSC 1176, paras 31–32 (India) (Criminal Appeal No. 611 of 2022, decided Nov. 7, 2022), https://indiankanoon.org/doc/149764625/.

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to the trial court record.[36] These decisions illustrate that the foundational validity of DNA science does not, without more, guarantee the applied validity of a particular laboratory result.

Nandlal Wasudeo Badwaik v. Lata Nandlal Badwaik, in which the Court held that a DNA test result must prevail over the conclusive presumption of legitimacy in Section 112 of the Evidence Act (now Section 116 of the Adhiniyam), shows the opposite risk: an over-correction in which DNA evidence is accorded a near-irrebuttable status that exceeds what forensic geneticists themselves would claim for a single test result.[37] Later decisions have tempered this tendency on privacy grounds, holding that DNA tests are not to be ordered as a matter of course but only where there is an "eminent need" for them.[38] India also still lacks a comprehensive statute on DNA testing and data protection of the kind found in several common law jurisdictions: the draft bill proposed by the Law Commission in 2017 led to the DNA Technology (Use and Application) Regulation Bill, 2019, which the Government withdrew from the Lok Sabha in July 2023, leaving accreditation, chain-of-custody protocols and laboratory proficiency testing to administrative practice and judicial direction rather than binding law.[39]

B. Narcoanalysis, polygraph and brain mapping

The most direct example of Indian courts grappling with the distinction between validity and admissibility is *Selvi v. State of Karnataka*, in which the Supreme Court held that the involuntary administration of narcoanalysis, polygraph examination and the Brain Electrical Activation Profile test violates the right against self-incrimination under Article 20(3) and the right to personal liberty under Article 21.[40] The Court also held that the results of these tests cannot be admitted as evidence even when the subject has consented to them, though information or material subsequently discovered with the help of voluntarily administered tests may be admitted under Section 27 of the Evidence Act, and it directed that the National Human Rights Commission's guidelines for the administration of polygraph tests be strictly followed.[41] Significantly, the Court did not rest its decision solely on constitutional grounds; it engaged,

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[36] *Kattavellai alias Devakar v. State of Tamil Nadu*, 2025 INSC 845, para 44 (India) (Criminal Appeal No. 1672 of 2019, decided July 15, 2025).

[37] *Nandlal Wasudeo Badwaik v. Lata Nandlal Badwaik*, (2014) 2 SCC 576, paras 12–15 (India).

[38] *Ashok Kumar v. Raj Gupta*, (2022) 1 SCC 20 (India); *Aparna Ajinkya Firodia v. Ajinkya Arun Firodia*, Civil Appeal arising out of SLP (C) No. 9855 of 2022 (India) (decided Feb. 20, 2023), https://api.sci.gov.in/supremecourt/2022/9691/9691_2022_15_1501_42221_Judgement_20-Feb-2023.pdf.

[39] Law Commission of India, Report No. 271, Human DNA Profiling: A Draft Bill for the Use and Regulation of DNA-Based Technology (2017), https://prsindia.org/files/bills_acts/bills_parliament/2018/Law%20Commission%20Report%20on%20DNA%20Profiling%20Bill_0.pdf; Aiman J. Chishti, *Centre Withdraws DNA Technology Regulation Bill 2019 From Lok Sabha*, LiveLaw (July 25, 2023), https://livelaw.in/news-updates/centre-withdraws-dna-technology-bill-lok-sabha-233563.

[40] *Selvi v. State of Karnataka*, (2010) 7 SCC 263, AIR 2010 SC 1974, paras 220–24 (India) (paragraph numbers as in the judgment delivered on May 5, 2010).

[41] *Id.* para 223.

unusually for an Indian judgment, with the scientific literature on each technique, noting that polygraph results carry a margin of error because the physiological responses measured may be triggered by nervousness, anxiety or fear rather than deception, that Dr. Lawrence Farwell's P300-based 'Brain Fingerprinting' technique had not been the subject of any rigorous independent study, and that narcoanalysis has no uniform criteria for evaluating its efficacy, can make subjects extremely suggestible to questioning and may elicit fanciful stories.[42] *Selvi* thus represents a rare moment in which scientific validity, rather than mere procedural propriety, entered directly into the reasoning of an Indian constitutional judgment, though it arrived through the vehicle of individual rights rather than through any general evidentiary methodology.

C. Fingerprint and bite-mark evidence

Fingerprint identification retains an almost unquestioned authority in Indian criminal trials, an authority traceable to the express recognition of finger impressions in Section 45 and to a long line of decisions treating a "positive" finding by a fingerprint expert as strong corroborative evidence. The high-water mark of this confidence is *Jaspal Singh v. State of Punjab*, in which the Supreme Court described the science of identifying thumb impressions as "an exact science" that "does not admit of any mistake or doubt".[43] This judicial confidence has rarely been tested against the discipline's actual empirical foundations. Indian courts have not systematically engaged with the international evidence that even trained examiners can err in latent print comparison, particularly where prints are partial or degraded, as the mistaken identification of Brandon Mayfield in the investigation of the 2004 Madrid train bombings and later black-box studies of examiner accuracy have shown.[44] Where the Supreme Court has rejected fingerprint evidence, it has done so on grounds of applied rather than foundational validity: in *Hari Om v. State of Uttar Pradesh*, it declined to rely on fingerprints where there was no evidence of the method by which they had been lifted and the person who lifted them was never examined.[45] Bite-mark evidence, though rare in Indian practice, was central in *Mukesh v. State (NCT of Delhi)*, where the Supreme Court treated as "wholly credible" a forensic odontologist's report matching bite marks on the victim to two of the accused and described forensic odontology as

[42] *Id.* paras 16, 47, 73.
[43] *Jaspal Singh v. State of Punjab*, AIR 1979 SC 1708 (India).
[44] Cole, *supra* note 29, at 1216–19; U.S. DEPARTMENT OF JUSTICE, OFFICE OF THE INSPECTOR GENERAL, A REVIEW OF THE FBI'S HANDLING OF THE BRANDON MAYFIELD CASE (2006), https://oig.justice.gov/sites/default/files/legacy/special/s0601/final.pdf; Bradford T. Ulery et al., *Accuracy and Reliability of Forensic Latent Fingerprint Decisions*, 108 PROC. NAT'L ACAD. SCIS. 7733 (2011), https://doi.org/10.1073/pnas.1018707108.
[45] *Hari Om v. State of Uttar Pradesh*, AIR 2021 SC 402, paras 30–32 (India) (Criminal Appeal No. 1256 of 2017, decided Jan. 5, 2021), https://indiankanoon.org/doc/52024378/.

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an "important and indispensable science", without sustained inquiry into the discipline's now well-documented unreliability.[46] That judgment was delivered in May 2017, some eight months after PCAST had concluded that bite-mark analysis was far from meeting the scientific standards for foundational validity.[47]

VI. Institutional and Regulatory Deficits

Beyond the doctrinal gap outlined above lie institutional weaknesses. Forensic science laboratories in India operate under varied administrative structures in different states, with uneven levels of accreditation and staffing, and there is no uniform or legally mandated proficiency testing programme of the kind recommended by the National Research Council.[48] An empirical study of thirty central, state and regional laboratories found that over 40 per cent of sanctioned posts in the laboratories reporting recruitment data were vacant, that only five of the laboratories studied were accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL), that most did not participate in proficiency testing, and that only four conducted statistical analysis of DNA results.[49] The Directorate of Forensic Science Services functions primarily as a coordinating and service-providing body rather than an independent scientific regulator with authority to set binding validation standards or to decertify unreliable techniques,[50] and the National Forensic Sciences University, established by statute in 2020, strengthens education and training capacity but has no regulatory mandate.[51] Nor is there a statutory body analogous to the Forensic Science Regulator for England and Wales, who, under the Forensic Science Regulator Act 2021, issues a statutory code of practice governing forensic science activities, including the validation of methods, with which forensic units must comply.[52]

The absence of institutional separation between investigative and forensic functions raises a further structural concern. Forensic laboratories in India are frequently administered by, or closely affiliated with, state police departments; in the study cited above, fifteen of the twenty-

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[46] *Mukesh v. State (NCT of Delhi)*, (2017) 6 SCC 1, paras 233–42 (India).
[47] PCAST Report, *supra* note 4, at 8–9.
[48] National Research Council, *supra* note 3, at 206–08, 215.
[49] Project 39A, Forensic Science India Report: A Study of Forensic Science Laboratories (2013–2017): Executive Summary 6, 15–16, 18 (National Law University Delhi 2023), https://web.archive.org/web/20231205203005/https://www.project39a.com/s/Executive-Summary-Forensic-Science-India-Report.pdf.
[50] Ministry of Home Affairs, *Directorate of Forensic Science (DFS)*, https://www.mha.gov.in/en/directorate-of-forensic-science-dfs (last visited Oct. 16, 2026).
[51] The National Forensic Sciences University Act, No. 32 of 2020, India Code (2020).
[52] Forensic Science Regulator Act 2021, c. 14, § 2 (UK); Forensic Science Regulator, Forensic Science Activities: Statutory Code of Practice (in force Oct. 2, 2023; withdrawn Mar. 6, 2026 on the publication of version 2), https://www.gov.uk/government/publications/statutory-code-of-practice-for-forensic-science-activities.

seven state and regional laboratories surveyed were under the administrative and financial control of the police department. Such an arrangement introduces a risk of cognitive bias: examiners who know the investigative theory behind a case may unconsciously read ambiguous forensic data in a way that fits that theory.[53] Research on contextual bias in forensic examination has shown that even highly trained examiners can be influenced by extraneous case information when that information is not deliberately withheld from them during analysis; procedures such as "sequential unmasking" and "linear sequential unmasking" have been advanced in the international forensic science literature to manage this risk, but are rarely, if ever, implemented in Indian practice.[54]

VII. Towards Reform: A Regulatory Framework

Bridging the gap between scientific validity and judicial admissibility requires reform at three distinct levels: doctrinal, institutional and procedural.

At the doctrinal level, Indian evidence law would benefit from the statutory incorporation of an explicit reliability threshold for forensic and other scientific expert testimony, modelled on Federal Rule of Evidence 702 as amended in 2023 and on the reliability factors of the Criminal Practice Directions in England and Wales, but adapted to the features already present in Indian criminal procedure. Such a provision, most naturally an addition to Section 39 of the Bharatiya Sakshya Adhiniyam, should require a court, before admitting novel or contested forensic evidence, to consider whether the underlying technique has been empirically tested, whether its error rate is known, and whether its application in the case before it followed a validated protocol, a formulation drawing on both the *Daubert* factors and PCAST's distinction between foundational validity and validity as applied.[55] A corresponding proviso to Section 329 of the Bharatiya Nagarik Suraksha Sanhita should require the scientific expert to be produced for examination whenever the accused disputes the validity of the method used.

At the institutional level, an independent forensic science regulator, empowered to accredit laboratories, mandate proficiency testing and issue binding validation codes for individual

[53] Project 39A, *supra* note 49, at 4; D. Michael Risinger et al., *The Daubert/Kumho Implications of Observer Effects in Forensic Science: Hidden Problems of Expectation and Suggestion*, 90 Calif. L. Rev. 1, 15–19 (2002), https://doi.org/10.2307/3481305.

[54] Itiel E. Dror & Greg Hampikian, *Subjectivity and Bias in Forensic DNA Mixture Interpretation*, 51 Sci. & Just. 204, 206–08 (2011), https://doi.org/10.1016/j.scijus.2011.08.004; Dan E. Krane et al., *Sequential Unmasking: A Means of Minimizing Observer Effects in Forensic DNA Interpretation*, 53 J. Forensic Scis. 1006 (2008), https://doi.org/10.1111/j.1556-4029.2008.00787.x; Itiel E. Dror et al., *Context Management Toolbox: A Linear Sequential Unmasking (LSU) Approach for Minimizing Cognitive Bias in Forensic Decision Making*, 60 J. Forensic Scis. 1111 (2015), https://doi.org/10.1111/1556-4029.12805.

[55] PCAST Report, *supra* note 4, at 4; *Daubert*, 509 U.S. at 593–94; Fed. R. Evid. 702; Criminal Practice Directions 2023, *supra* note 20, paras 7.1.1–7.1.3.

forensic disciplines, would supply the gatekeeping infrastructure that individual trial judges cannot realistically provide case by case. NABL accreditation could, for instance, be made a condition for any laboratory whose reports are to be received under Section 329 of the Sanhita. Such a body could draw on the working model of the Organization of Scientific Area Committees for Forensic Science of the National Institute of Standards and Technology in the United States, which develops discipline-specific standards through committees of practising scientists, statisticians and legal experts, and on the statutory code of practice of the Forensic Science Regulator for England and Wales.[56]

At the procedural level, a pre-trial admissibility hearing dedicated to contested forensic evidence, conducted before a judge with the assistance of a neutral, court-appointed scientific adviser rather than solely party-nominated experts, would reduce the asymmetry between prosecution and defence resources that currently undermines meaningful adversarial testing.[57] Legal aid frameworks would also need to guarantee indigent defendants access to independent forensic review, since the theoretical availability of cross-examination is of little practical value where the defence cannot afford to instruct a rebuttal expert.

Finally, structured teaching on the epistemology of forensic science should be introduced in judicial training, both initial and continuing, at the State judicial academies and the National Judicial Academy, so that the gatekeeping function is performed by judges equipped to distinguish genuine scientific consensus from mere professional custom.[58]

VIII. Conclusion

The presumptive authority of forensic evidence in a modern criminal trial rests on an assumption that admissibility is synonymous with reliability: if an expert's opinion is placed before the court, the technique on which it rests is taken to have been shown to be reliable. This paper has shown that the assumption does not hold even in the United States, where the *Daubert* regime has established an elaborate framework of gatekeeping principles, and holds still less in India, where the Evidence Act and its 2023 successor focus on the qualifications of the witness rather than on the scientific merit of the technique.

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[56] National Institute of Standards and Technology, *The Organization of Scientific Area Committees for Forensic Science*, https://www.nist.gov/organization-scientific-area-committees-forensic-science (last visited Oct. 16, 2026); Forensic Science Regulator, *supra* note 52.

[57] *Daubert*, 509 U.S. at 595 (noting the court's power under Federal Rule of Evidence 706 to appoint an expert of its own choosing); Giannelli, *Ake v. Oklahoma*, *supra* note 30.

[58] *Cf.* PCAST Report, *supra* note 4, at 144–45 (recommending that the Federal Judicial Center develop educational programs on procedures for evaluating the scientific validity of forensic feature-comparison methods).

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The coming decade will show whether India can bring scientific rigour to the ordinary law of evidence by adopting a statutory reliability threshold, an independent forensic regulator and procedural devices that give meaning to the difference between what science has demonstrated and what courts are willing to believe. The Supreme Court's recent insistence on chain-of-custody safeguards for DNA evidence is a welcome beginning, but directions issued in individual cases cannot substitute for a general legislative framework. Without such changes, the criminal justice system will continue to convict and acquit on the basis of methods that enjoy more credibility in court than in the laboratory, a gap that only deliberate legal design can close.

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