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THE ROLE OF FORENSIC SCIENCE IN CRIMINAL CONVICTION

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Abstract

Forensic science occupies a position of unique authority in the criminal justice system, often perceived as an objective arbiter of truth capable of delivering certainty where other forms of evidence fall short. This paper critically examines the role of forensic science in criminal conviction, arguing that its contribution is more complex and ambivalent than the prevailing narrative suggests. Drawing on empirical research from multiple jurisdictions, including studies of 92 Canadian wrongful convictions and 759 sexual assault exonerations, this analysis demonstrates that forensic evidence has been instrumental both in securing convictions of the guilty and in exonerating the innocent. However, the same evidence reveals that forensic science is also implicated in miscarriages of justice not primarily authority, and judicial gatekeeping. The paper analyses the evolution of forensic admissibility standards, the persistent challenges posed by cognitive bias and institutional deference, and the paradoxical effect of DNA evidence as both a corrective mechanism and a source of tunnel vision. It concludes that forensic science's role in criminal conviction depends less on the intrinsic reliability of scientific methods than on the institutional frameworks and human judgement that mediate their application. Strengthening this role requires not merely better science, but better oversight, enhanced scientific literacy among legal actors, and a more honest reckoning with the limits of forensic evidence.

Introduction

The relationship between forensic science and criminal conviction rests on a compelling promise: that science can deliver what human judgement alone cannot certainty. In an adversarial system built on contestable narratives, ambiguous memories, and fallible perception, forensic evidence offers the allure of objectivity. A DNA profile matching a suspect to a crime scene with a probability of one in a trillion seems to transcend reasonable doubt. It is this promise that has elevated forensic science to a cornerstone of modern criminal justice, shaping investigations, trials, and public confidence in the legitimacy of convictions.

Yet this promise is fraught with tension. The same forensic techniques that convict also exonerate. The Innocence Project, through post-conviction DNA testing, has overturned hundreds of wrongful convictions, many of which involved flawed forensic evidence¹. The National Academy of Sciences, in its landmark 2009 report, concluded that with the exception of DNA analysis, most forensic disciplines lack rigorous scientific validation.² These findings expose a troubling paradox: forensic science is simultaneously the most powerful tool for convicting the guilty and a significant contributor to convicting the innocent.

This paper examines the role of forensic science in criminal conviction through a critical lens, asking not whether forensic evidence is reliable, but how and under what conditions it contributes to just outcomes. Drawing on empirical studies of wrongful convictions, analyses of judicial gatekeeping, and research on forensic decision-making, it argues that the impact of forensic science on conviction is mediated by systemic factors institutional authority, cognitive bias, legal standards, and the scientific literacy of legal actors that are often overlooked in policy discussions.

The analysis proceeds in five parts. Section 2 traces the theoretical framework of forensic evidence, distinguishing between its potential and its limits. Section 3 examines the empirical evidence on forensic science's contribution to both convictions and exonerations. Section 4 analyses the judicial gatekeeping function, comparing admissibility standards across jurisdictions. Section 5 explores systemic vulnerabilities: cognitive bias, institutional authority, and the gap between forensic practice and scientific ideals. Section 6 considers the path forward, proposing reforms to strengthen forensic science's role in just conviction. The conclusion reflects on the deeper lesson: that forensic science is neither saviour nor scourge, but a human institution requiring constant scrutiny and reform.

Theoretical Framework: The Promise and Limits of Forensic Evidence

Defining Forensic Science's Evidentiary Function

Forensic science serves two distinct but related functions in the criminal justice system. The first is investigative: forensic techniques generate leads, link crimes, and help identify suspects. The second is evidential: forensic findings provide proof in court, supporting or undermining the prosecution's case. These functions are often conflated, but they operate under different standards. Investigative uses may tolerate greater uncertainty; evidential uses demand rigorous validation because they bear directly on liberty and life.

¹ Innocence Project, materials concerning post-conviction DNA testing and DNA exonerations.

² National Academy of Sciences, Strengthening Forensic Science in the United States: A Path Forward (2009).

The evidentiary function rests on inference: from a trace found at a crime scene to a conclusion about its source or significance. This inferential chain is vulnerable at every link. Collection and preservation may contaminate or degrade samples.

Laboratory analysis may produce erroneous results. Statistical interpretation may misrepresent the weight of evidence. And the communication of findings to judges and juries may oversimplify or distort. Each vulnerability represents a point where forensic science's contribution to conviction can go awry.³

The Gold Standard and Its Limits

DNA profiling stands apart from other forensic disciplines as the only technique widely regarded as scientifically validated. Its power lies in its basis in population genetics, its demonstrable error rates, and its capacity for blind testing and peer review. Since its introduction in the late twentieth century, DNA has become the gold standard against which other forensic methods are measured.⁴

Yet even DNA evidence is not infallible. Contamination, laboratory errors, chain-of-custody failures, and misinterpretation can compromise its reliability. The President's Council of Advisors on Science and Technology, while acknowledging DNA's validity, identified ongoing concerns about the interpretation of complex DNA mixtures and the statistical presentation of results.⁵ The problem is not that DNA is unreliable, but that its perceived infallibility creates complacency, leading courts and jurors to overestimate its probative value and overlook potential flaws.

Types of Error: False Convictions and Unsolved Crimes

Forensic errors can be understood as two distinct types. Type I errors false positives occur when forensic evidence contributes to the conviction of an innocent person. Type II errors false negatives occur when forensic evidence fails to solve a crime, leaving perpetrators unpunished and alternative hypotheses unexplored. Both undermine justice, yet they are often treated asymmetrically. Wrongful convictions attract scrutiny and advocacy; cold cases receive far less attention.

This asymmetry has consequences. Research on Canadian wrongful convictions found that in 30 of 92 cases, forensic science played a role, but 97 percent of the errors stemmed from

⁴ President's Council of Advisors on Science and Technology, *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods* (2016).

⁵ National Academy of Sciences, *Strengthening Forensic Science in the United States: A Path Forward* (2009).

⁶ President's Council of Advisors on Science and Technology, *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods* (2016).

misinterpretation or overstatement of reliable results, not from analytical failures.⁶ Conversely, an exploratory study of French cold cases found that the potential of forensic traces was systematically underestimated, with investigative tunnel vision and resource constraints preventing alternative hypotheses from being generated. Together, these findings suggest a systemic vulnerability: forensic science is overestimated when it points to guilt and underestimated when it could point elsewhere.

Forensic Science and Conviction: Empirical Evidence

Forensic Evidence as a Factor in Wrongful Convictions

The empirical literature on wrongful convictions provides sobering insights into forensic science's role in miscarriages of justice. A study of 759 sexual assault exonerations from the National Registry of Exonerations found that flawed forensic evidence was a significant contributing factor, alongside eyewitness misidentification⁷, false confessions, and official misconduct. The persistence of these factors, even in the DNA era, suggests that forensic reform alone cannot solve the broader problems of the justice system.

Canadian research reinforces this finding. In 92 officially recognized wrongful convictions, science played a role in nearly one-third of cases. Crucially, the errors were overwhelmingly interpretative: experts overstated the significance of findings, exceeded the probative value of evidence, or confused levels of interpretation. This pattern reliable science, unreliable interpretation—points to a failure of forensic oversight and judicial understanding rather than a failure of laboratory technique.

DNA's Dual Role: Exoneration and Tunnel Vision

DNA evidence has been the primary driver of exonerations, with the Innocence Project and similar organizations using post-conviction testing to overturn hundreds of wrongful convictions⁸. This corrective function is forensic science's most celebrated contribution to justice. Yet it also reveals the scope of the problem: if DNA testing is required to expose miscarriages, it suggests that the initial trials which often included non-DNA forensic evidence failed to protect the innocent⁹.

Moreover, the success of DNA has created unintended consequences. Overreliance on DNA evidence may lead to tunnel vision among law enforcement agencies, who focus on cases with

⁷ S.J. Lécuyer & F. Crispino, "Exploratory Research: Is Forensic Science a Cause of Miscarriage of Justice in Canada?," *Forensic Science International: Synergy*, Vol. 12 (2026).

⁸ M. Sorochinski, M. Sigman & E. Borukhov, "Wrongful Convictions in Sexual Assault Cases: DNA Testing, Evidentiary Failures, and Policy Lessons from 35 Years of Exonerations," *Journal of Criminal Justice* (2026).

⁹ Innocence Project, materials concerning post-conviction DNA testing and DNA exonerations.

¹⁰ M. Selvapriya & B. Mathanachandiran, "DNA Evidence and its Impact on Wrongful Convictions in Criminal Justice: A Critical Analysis," *International Journal of Law Management & Humanities*, Vol. 9 (2026).

biological evidence while neglecting those that lack it. This skews investigative resources and may exacerbate disparities in case outcomes, as sexual assaults without DNA evidence receive less attention and may be more likely to result in flawed convictions.¹⁰ The lesson is that even the gold standard, when applied unevenly, can produce injustice.

The Interpretation Gap

The most consistent finding across empirical studies is that forensic errors are less about faulty science than about faulty interpretation. Canadian research identified a 97 percent rate of interpretive errors among cases where science contributed to wrongful convictions. Dutch research found that criminal justice professionals judges, prosecutors, and defence lawyers struggled to distinguish between sound and unsound forensic reports, and that reports from reputable institutions received less critical scrutiny.¹¹

This interpretation gap has multiple causes. Forensic experts often communicate findings in probabilistic terms that legal actors are ill-equipped to understand.

Prosecutors may overstate the significance of matches, committing the "prosecutor's fallacy" confusing the probability of evidence given innocence with the probability of innocence given evidence. Judges, lacking scientific training, defer to expert authority rather than interrogating methodology. And the adversarial system, which assumes that cross-examination will expose weaknesses, is poorly suited to correcting misunderstandings of complex science.

Judicial Gatekeeping: Admissibility Standards and Their Limits

From Frye to Daubert: The US Experience

The admissibility of forensic evidence in US courts is governed by a framework that has evolved significantly over the past century. The Frye standard (1923) required that a scientific technique be "generally accepted" in its field before it could be admitted. This standard was criticized for being conservative and deferential to scientific communities that were themselves unvalidated. The Daubert standard (1993) sought to strengthen gatekeeping by requiring judges to assess reliability directly. Under Daubert and the Federal Rules of Evidence, judges must consider whether a technique has been tested, subjected to peer review, has known error rates, and is generally accepted. This approach was intended to make admissibility decisions more scientifically rigorous.

However, implementation has been uneven. Studies show that judges rarely apply Daubert factors

¹¹ M. Sorochinski, M. Sigman & E. Borukhov, "Wrongful Convictions in Sexual Assault Cases: DNA Testing, Evidentiary Failures, and Policy Lessons from 35 Years of Exonerations," *Journal of Criminal Justice* (2026)

¹² R.H.D. de Roo, L. Stevens & C.J. de Poot, "The Impact of Institutional Authority on Forensic Evidence Evaluation by Criminal Justice Professionals," *Journal of Forensic Sciences* (2025).

rigorously, often deferring to precedent rather than conducting independent reliability assessments. Cognitive biases information cascades, status quo bias, and overreliance on established practices lead judges to admit techniques that have been accepted for decades, even when new scientific evidence challenges their validity¹². The result is that forensic evidence continues to be admitted without adequate scrutiny, perpetuating the problems identified by the NAS and PCAST reports¹³.

Comparative Perspectives: Canada and India

Other jurisdictions have adopted different approaches, with mixed results. Canada, like the US, has struggled with forensic errors, as the Canadian wrongful convictions study demonstrates¹⁴. The Canadian registry includes cases spanning six decades, revealing persistent problems with expert testimony and judicial understanding. The study's authors recommend stronger forensic oversight, improved scientific literacy, and frameworks that address the inherent uncertainty of forensic evidence. India's approach is in transition. The Bharatiya Sakshya Adhiniyam, 2023, replaces the colonial Indian Evidence Act but retains its framework for expert testimony. Section 39 admits expert opinions on matters of science or art, while Sections 40 and 44 allow scrutiny of underlying facts and reasoning. However, like its predecessor, the new statute is silent on the reliability of scientific techniques, leaving judges to develop ad hoc standards. Indian courts have evolved a pragmatic approach requiring corroboration, but without codified reliability thresholds, inconsistency and unpredictability persist¹⁵.

The Indian experience highlights a broader challenge: absent clear legislative guidance, judges must become scientific gatekeepers without scientific training. This problem is not unique to India but is exacerbated by uneven forensic infrastructure and limited judicial education.

The Challenge of Cutting-Edge Science

The rapid evolution of forensic technologies compounds the gatekeeping challenge. New techniques forensic genealogy, biometric identification, algorithmic analysis offer powerful investigative tools but often lack the validation required for evidentiary use. Courts must decide whether to admit evidence based on novel methods without the benefit of established scientific consensus or error-rate data.

¹³ S. Gordon, "Old Habits Die Hard: Precedent, Psychology, and the Admissibility of Forensic Evidence," University of Toronto Law Journal (2025).

¹⁴ National Academy of Sciences, Strengthening Forensic Science in the United States: A Path Forward (2009).

¹⁵ S.J. Lécuyer & F. Crispino, "Exploratory Research: Is Forensic Science a Cause of Miscarriage of Justice in Canada?," Forensic Science International: Synergy, Vol. 12 (2026).

¹⁶ S.G.S. Gowda, "Forensic Science and Indian Law: Navigating the Standards of Admissibility and Evidentiary Value of Scientific Evidences in Indian Jurisprudence," International Journal of Law Management & Humanities

The NAS and PCAST reports emphasized that with the exception of DNA and fingerprint analysis, most forensic feature-comparison methods lack rigorous scientific validation. Yet courts continue to admit hair comparison, bite-mark analysis, and other techniques that have been discredited. This persistence reflects both institutional inertia and the difficulty of rejecting evidence that has been accepted for decades. The challenge for the future is to develop gatekeeping framework that is both scientifically rigorous and practically workable, capable of distinguishing reliable science from unvalidated conjecture.

Systemic Vulnerabilities in Forensic Practice

Cognitive Bias and Contextual Influence

Cognitive biases affect forensic decision-making at multiple levels. Forensic examiners, like all humans, are susceptible to confirmation bias: the tendency to interpret evidence in ways that support pre-existing hypotheses. In forensic contexts, this means that examiners who know the circumstances of a case or the suspect's identity may unconsciously interpret ambiguous features to align with the prosecution's theory.

Research has demonstrated that contextual information influences forensic judgments. Fingerprint examiners who are given contextual cues about a case are more likely to match prints to suspects than those who work blind. Blood-pattern analysts, DNA analysts, and other experts show similar patterns. The problem is not that examiners are deliberately biased, but that bias operates outside conscious awareness, making it difficult to detect or correct.

The Canadian wrongful convictions study found that many interpretative errors involved "confusion between levels of interpretation" experts overstepping the probative value of their findings¹⁶. This suggests that bias may operate not only in laboratory analysis but in the communication of results, as experts implicitly adopt the prosecution's perspective.

Institutional Authority and Deference

Forensic evidence carries weight not only because of its scientific basis but because of the institutional authority of its sources. Research in the Netherlands found that criminal justice professionals were unable to distinguish sound from unsound forensic reports, and that reports from well-known institutes received less

¹⁷ S.J. Lécuyer & F. Crispino, "Exploratory Research: Is Forensic Science a Cause of Miscarriage of Justice in Canada?," *Forensic Science International: Synergy*, Vol. 12 (2026).

critical examination¹⁷. This "institutional authority effect" increases the risk that flawed evidence will be accepted without scrutiny.

The problem is compounded by the complexity of forensic science. Judges, prosecutors, and defence lawyers lack the training to evaluate scientific methodology, so they rely on proxies: the reputation of the expert, the accreditation of the laboratory, and the credentials of the institution. These proxies are imperfect. Accredited laboratories can still make errors. Reputable experts can overstate their findings. And institutional authority can mask incompetence or fraud.

The Dutch case of the "Rosmalense flatmoord" illustrates the danger. Forensic experts from a reputable institute made overly assertive claims that shaped the verdict. During the case review, new reports highlighted the unsubstantiated nature of these claims, leading to acquittal. The case underscores that institutional authority is not a guarantee of reliability and that judicial scrutiny must extend beyond credentials to methodology and reasoning.

The Gap Between Forensic Science and Scientific Ideals

The NAS and PCAST reports identified a fundamental problem: most forensic disciplines have not been subjected to the scientific validation required of other fields. While DNA analysis meets rigorous standards, disciplines like bite-mark analysis, hair comparison, and even some aspects of fingerprinting lack empirical testing, error-rate analysis, and peer review¹⁸. Yet these methods are routinely admitted in court.

This gap between forensic practice and scientific ideals persists for multiple reasons. First, forensic disciplines developed within law enforcement, not within academic science, and were shaped by investigative needs rather than scientific standards. Second, validation studies are expensive and time-consuming, and forensic laboratories are underfunded and understaffed. Third, courts have been slow to require validation, accepting historical use as a proxy for reliability.

The result is that forensic science operates in a space between law and science, subject to the standards of neither fully. This liminal status creates risks for criminal conviction: evidence that appears scientific but lacks scientific validity can mislead judges and juries, contributing to wrongful convictions.¹⁹

¹⁸ R.H.D. de Roo, L. Stevens & C.J. de Poot, "The Impact of Institutional Authority on Forensic Evidence Evaluation by Criminal Justice Professionals," *Journal of Forensic Sciences* (2025).

¹⁹ President's Council of Advisors on Science and Technology, *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods* (2016).

²⁰ National Academy of Sciences, *Strengthening Forensic Science in the United States: A Path Forward* (2009).

Strengthening Forensic Science's Role in Just Conviction

Improving Forensic Oversight

The evidence from multiple jurisdictions points to the need for stronger forensic oversight throughout the investigative and judicial process. Canadian researchers recommend "a stronger forensic oversight all along the investigative process" to address the systemic vulnerabilities that contribute to both wrongful convictions and unsolved crimes²⁰. This oversight should extend from crime-scene processing to laboratory analysis to courtroom testimony, with checks and balances at each stage.

One model is the independent forensic oversight body proposed by the NAS report, which would set standards, accredit laboratories, and conduct research. Such a body could ensure that forensic techniques are validated before they are used in court, and that laboratories are held to consistent quality standards. However, implementation has been slow, and political resistance has hindered reform.

Enhancing Scientific Literacy Among Legal Actors

The interpretation gap between forensic science and legal decision-making requires attention. Judges, prosecutors, and defence lawyers need training in scientific methodology, statistics, and the limits of forensic evidence. Without this training, they cannot effectively perform the gatekeeping function that the law assigns them.

Judicial education programs, like those offered by the US Federal Judicial Centre, have had some success in improving judges' understanding of scientific evidence. However, such programs are optional, and many judges do not participate. The Canadian and Indian studies both highlight the need for more systematic training, including curricula on statistical reasoning, cognitive bias, and the critical evaluation of expert testimony²¹.

Reforming Admissibility Standards

The admissibility of forensic evidence should be governed by rigorous reliability standards. The Daubert framework provides a useful starting point, but its application has been uneven.²² Courts should be required to consider error rates,

²¹ S.J. Lécuyer & F. Crispino, "Exploratory Research: Is Forensic Science a Cause of Miscarriage of Justice in Canada," *Forensic Science International: Synergy*, Vol. 12 (2026).

²² D. Saraf & V.V. Nair, "Understanding the Role of Forensic Expert Testimony in New Criminal Laws to Increase Conviction Rate in the Indian Criminal Justice System," *International Journal of Public Law and Policy*, Vol. 12, No. 2, pp. 193–210 (2026).

²³ *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993)

peer review, and empirical validation, rather than deferring to precedent or general acceptance.²³

The Sydney Declaration, a framework proposed by forensic experts, offers a conceptual foundation for reform. It refocuses forensic science on the "trace" the foundational concept of forensic evidence and emphasizes the need to address inherent complexity and uncertainty. Adopting such a framework would encourage a more honest reckoning with the limits of forensic evidence and discourage overstatement.

Addressing Cognitive Bias

Reducing the influence of cognitive bias requires changes in forensic practice. Blind testing where examiners are not given contextual information about a case can reduce confirmation bias. Sequential unmasking where contextual information is revealed gradually can help examiners distinguish between legitimate inferences and bias-driven interpretations. And the use of multiple independent examiners can provide a check on individual error.

These measures require resources and a cultural shift in forensic laboratories. Many laboratories are resistant to blind testing, viewing it as impractical or unnecessary.

Yet the evidence on cognitive bias suggests that it is essential for accurate forensic decision-making. Training forensic examiners in the psychology of bias can help them recognize and mitigate its effects.

Universal DNA Testing and Beyond

The success of DNA testing in exonerating the innocent suggests that it should be used more broadly. Universal DNA testing, where feasible, could identify perpetrators, clear suspects, and prevent wrongful convictions. However, such testing must be accompanied by protocols that ensure the preservation and integrity of biological evidence, and by safeguards against the misuse of DNA databases.

At the same time, reform must extend beyond DNA. Most criminal cases do not involve biological evidence, and relying exclusively on DNA leaves many cases vulnerable to the same errors that have plagued forensic practice for decades. Improving non-DNA forensic disciplines—through validation, training, and oversight is essential for a just system.

governing the admissibility of expert testimony in U.S. federal courts.

²⁴ Federal Rules of Evidence, Rule 702,

Conclusion

The role of forensic science in criminal conviction is neither simple nor stable. It is a powerful tool that has convicted the guilty and exonerated the innocent, yet it has also contributed to miscarriages of justice through misinterpretation, overstatement, and institutional deference. The empirical evidence from Canada, the United States, India, and the Netherlands reveals that forensic errors are less about faulty laboratory techniques than about the human systems that mediate the translation of science into evidence.

This finding carries a sobering implication: forensic science cannot be reformed simply by improving the science. It requires a broader overhaul of the institutional frameworks that shape its use. Stronger oversight, better training for legal actors, rigorous admissibility standards, and measures to counter cognitive bias are all essential. So too is a cultural shift a recognition that forensic evidence is not a source of certainty but a form of inference, always provisional, always subject to error, and always requiring critical scrutiny. The path forward is not to abandon forensic science but to hold it to its own ideals. The same scientific methods that have revolutionized criminal justice must be applied to forensic practice itself: validation, peer review, error analysis, and continuous improvement. Only then can forensic science fulfil its promise not as an infallible arbiter, but as a reliable contributor to just convictions.