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# The Evolution of Scientific Evidence Theory in Criminal Law: A Transformative Insight

**Handar Subhandi Bakhtiar**
Faculty of Law, Universitas Pembangunan Nasional "Veteran" Jakarta, Indonesia.
E-mail: handar_subhandi@yahoo.com

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**Abstract**
Criminal law evolution accentuates the contrast between traditional eyewitness testimonies and precise modern forensics. While testimonies offer depth, scientific methodologies provide unparalleled accuracy in investigations. This study examines the challenges and merits of both in light of technological advancements. The objective is to understand the evolving paradigm of scientific evidence in criminal justice, emphasizing its integration and balance with traditional evidentiary methods for upholding judicial integrity and revealing material truth. The result of this study is historical evolution in the theory of scientific evidence which has transitioned from relying on testimonies to verifiable scientific data, including advancements in DNA and cyber technology. This scientific approach, characterized by its objectivity, replicability, and measurability, offers a robust foundation for discerning truth and justice, surpassing the limitations of mere factual accounts. Modern criminal law's integration of this evidence signifies a deep-rooted commitment to justice, ensuring verdicts are swift, fair, and grounded in undeniable truth.



## Introduction

Legal advancements are deeply intertwined with the shifting dynamics and challenges of their epoch.[1] Within criminal law, the ongoing debate between scientific and factual evidence has garnered attention, inviting more profound exploration. Both types of evidence are instrumental in deciding an individual's destiny in court, each carrying its distinct challenges and attributes. Traditionally, in the realm of the criminal justice system, factual evidence has stood as the cornerstone of the trial process.[2] Testimonies from witnesses, insights from experts, written correspondences, indicative evidence, and statements from the accused collectively serve as the foundation for determining one's culpability in a criminal act.[3]

[1] Bambang Waluyo, *Penegakan Hukum Di Indonesia* (Sinar Grafika 2022).

[2] Rifka Safia, Elda Meisy Rahmi and Sela Nurhayati, 'Bentuk Perlidungan Hukum Dari Lembaga Perlindungan Saksi/Korban Di Indonesia Dan Inggris' (2022) 1 Jurnal Ekonomi, Bisnis dan Humaniora <https://eksishum.untara.ac.id/index.php/eksishum/article/view/12>.

[3] Handar Subhandi Bakhtiar, 'Pentingnya Bukti Forensik Pada Pembuktian Tindak Pidana' (2022) 3 Jurnal Hukum Pidana dan Kriminologi 36 <http://jurnalmahupiki.org/ojs/index.php/jhpk/article/view/82>.

In earlier times, witness accounts and tangible evidence were primary determinants within the legal framework, largely due to the constraints of available technology. However, with the progression of science and technology, scientific evidence has made its mark in the criminal justice system.[4] Innovations in forensics, including DNA testing and fingerprint analyses, present a level of precision that towers over traditional methods of evidence.[5] In today's context, something as minuscule as a hair strand or skin flake might play a pivotal role in associating someone with a criminal act. While scientific evidence seemingly offers enhanced accuracy, its integration into the legal system is accompanied by a slew of challenges. Questions arise, such as how can we validate the reliability of these technologies, what are the repercussions when data are mishandled or misinterpreted, and how should one balance scientific evidence against its factual counterpart in judicial proceedings. Another pressing concern is the evident gap in technological comprehension and the understanding of scientific evidence amongst legal professionals. It's entirely plausible that potent scientific evidence might be sidestepped in courtrooms due to misunderstandings on the part of judges, prosecutors, or legal counsellors.[6]

In the digital era and advances in information technology, types of crime are increasingly diverse and complex. Take cybercrime as an example; it necessitates robust and credible digital evidence to convincingly establish the guilt of the offender.[7] In such scenarios, traditional factual evidence might often take a backseat or be entirely absent. Yet, despite these shifts, factual evidence retains a significant foothold within the criminal justice framework. While scientific evidence extends precision and objectivity, factual evidence frequently encapsulates context and subtleties often elusive to pure scientific methodologies. Consider eyewitness accounts; they often convey an emotional and psychological dimension to an event, a depth that's challenging to capture through

[4] M Ali Zaidan, *Menuju Pembaruan Hukum Pidana* (Sinar Grafika 2022).

[5] Sidharth Kumar Pathak, 'Forensic Science's Impact: DNA Tests and Narco-Analysis Evidentiary Relevance' (2022) 2 Jus Corpus Law Journal 531.

[6] Athaliah Biju, Kate Hambly and Avani Joshi, 'The Complexity of Forensic Science in Criminal Investigations: Is There a Gold Standard?' (2021) 1 Voices of Forensic Science.

[7] Loene M Howes, 'The Communication of Forensic Science in the Criminal Justice System: A Review of Theory and Proposed Directions for Research' (2015) 55 Science & Justice, 145–154 <https://linkinghub.elsevier.com/retrieve/pii/S1355030614001397>.

purely scientific means. Set against this backdrop, a primary challenge confronting the criminal justice system is the harmonization of scientific and factual evidence. It's crucial to strike a balance, ensuring each form of evidence is accorded its due weight and consideration, all the while upholding the tenets of integrity and fairness throughout the judicial process. The objective of this research is to delve into the evolving paradigm of the scientific evidence theory, particularly in light of the swift advancements in technology and science and their influence on criminal law enforcement and it is hoped that this research will provide comprehensive knowledge for both academics and law enforcement officials on the theory of scientific evidence in criminal law.

**Research Method**

This study is a qualitative study that utilizes a historical approach to trace the direction of the development of the theory of scientific evidence in Indonesia and a conceptual approach to examine and analyze opinions and debates in the development of scientific evidence. The research hinges on a literature review, wherein relevant academic articles and research papers on the scientific evidence theory are analyzed. The amassed materials undergo a prescriptive analysis, furnishing a holistic overview of the scientific evidence theory's development within criminal law.

**The Evolution of the Theory of Scientific Evidence**

The interplay between science and the criminal justice system has seen significant changes over the years, most notably in the evolution of scientific evidence used within legal contexts.[8] Initially, scientific evidence in courtrooms was rudimentary, based on basic applications.[9] Although these methods developed rapidly, they lacked the

[8] Troy Duster, 'A Post-genomic Surprise. The Molecular Reinscription of Race in Science, Law and Medicine' (2015) 66 The British Journal of Sociology 1 <https://onlinelibrary.wiley.com/doi/10.1111/1468-4446.12118>. See also, Brian W Head, 'Toward More "Evidence-Informed" Policy Making?' (2016) 76 Public Administration Review 472 <https://onlinelibrary.wiley.com/doi/10.1111/puar.12475>.

[9] Jane Donoghue, 'The Rise of Digital Justice: Courtroom Technology, Public Participation and Access to Justice' (2017) 80 The Modern Law Review 995 <https://onlinelibrary.wiley.com/doi/10.1111/1468-2230.12300>. See also, Bernard Robertson, GA Vignaux and Charles EH Berger, *Interpreting Evidence: Evaluating Forensic Science In The Courtroom* (John Wiley & Sons 2016) <https://onlinelibrary.wiley.com/doi/book/10.1002/9781118492475>.

precision and credibility of contemporary advanced techniques. As science advanced, its application in the legal realm followed suit. The transition from these elementary methods to more sophisticated and reliable techniques marks a pivotal transformation in criminal law and its evidentiary standards.[10] Today, cutting-edge scientific techniques, from DNA analysis to digital forensics, stand as crucial foundations in legal proceedings.[11] Their incorporation into the judicial process hasn't merely improved the accuracy and dependability of evidence but has also set new benchmarks for proof in many instances. This significant evolution isn't just indicative of advancements in science and its role in criminal probes.[12] More deeply, it reflects society's growing confidence in empirical methods as tools to unveil the truth. As we've become more reliant on scientific evidence, it symbolizes society's faith in the objectivity and rigor of scientific investigation.

**1. Early Beginnings**

Historically, the application of scientific evidence within the legal environment in Indonesia has not been a primary concern. Criminal trials relied strongly on testimonial and circumstantial evidence, rather than the systematic application of science.[13] Consider ancient legal traditions, such as those in Greece and Rome: these civilizations placed considerable emphasis on witness accounts and confessions, which were regrettably

[10] Humaira Arshad, Aman Bin Jantan and Oludare Isaac Abiodun, 'Digital Forensics: Review of Issues in Scientific Validation of Digital Evidence' (2018) 14 Journal of Information Processing Systems. See also, Peter Kraska, John Brent and W Lawrence Neuman, *Criminal Justice and Criminology Research Methods* (Routledge 2020) <https://www.routledge.com/Criminal-Justice-and-Criminology-Research-Methods/Kraska-Brent-Neuman/p/book/9780367133948>.

[11] Helena Machado and Rafaela Granja, *Forensic Genetics in the Governance of Crime* (Springer Nature 2020) <https://library.oapen.org/handle/20.500.12657/23264>. See also, Dragan Primorac and Moses Schanfield, *Forensic DNA Applications* (CRC Press 2023) <https://www.taylorfrancis.com/books/9780429019944>. See also, Chuck Easttom, *System Forensics, Investigation, and Response* (Jones & Bartlett Learning 2017).

[12] Jessica Gabel Cino, 'Tackling Technical Debt: Managing Advances in DNA Technology That Outpace the Evolution of Law' (2016) 05 Journal of Civil & Legal Sciences <http://www.omicsgroup.org/journals/tackling-technical-debt-managing-advances-in-dna-technology-thatoutpace-the-evolution-of-law-2169-0170-1000183.php?aid=70590>. See also, Eric J Engstrom, *Forensic Psychiatry: Human Science in the Borderlands Between Crime and Madness, In The Palgrave Handbook of the History of Human Sciences* (Springer Singapore 2022).

[13] Henry Prakken and Hendrik Kaptein, *Legal Evidence and Proof: Statistics, Stories, Logic* (Routledge 2016). See also, M Chris Fabricant and William Tucker Carrington, 'The Shifted Paradigm: Forensic Sciences's Overdue Evolution from Magic to Law' (2016) 4 Virginia Journal of Criminal Law <http://www.ssrn.com/abstract=2572480>.

sometimes acquired through coercion or even torture.[14] While rudimentary forensic methods, like inspecting physical injuries, were occasionally used by these early societies, they weren't consistent or systematic. This absence of a standardized approach meant that justice was often a matter of subjective interpretation rather than empirical evidence.[15] The historical reliance on human testimony, inherently susceptible to error or manipulation, underscores the monumental shift we've witnessed in modern times. The evolution of legal proceedings now places scientific methodology at its heart, in stark contrast to the ancient practices that depended heavily on the unreliable human memory and perception.[16] The shift from these early systems to our current evidence-based judicial process emphasizes the significant advancements in our pursuit of justice, driven largely by the constantly advancing world of science.[17]

**2. Emergence of Forensics**

During the 19th century, Indonesia was under Dutch colonial rule, and forensic practices were influenced by European developments.[18] The Dutch East Indies, as it was known, saw the introduction of modern legal systems and investigative methods. Forensic techniques, however, were still in the early stages of development compared to contemporary standards. The early 20th century witnessed a gradual modernization of legal and forensic practices in Indonesia. The Dutch colonial administration played a role in introducing more systematic approaches to crime investigation.[19] However,

[14] B Marco, 'Human Rights Violations: Torture And Deprivation Of Liberty Examined' (2022) 7 Academic Journal of Legal Studies and Research.

[15] Madeleine C McKinnon and others, 'What Are the Effects of Nature Conservation on Human Well-Being? A Systematic Map of Empirical Evidence from Developing Countries' (2016) 5 Environmental Evidence 8 <https://environmentalevidencejournal.biomedcentral.com/articles/10.1186/s13750-016-0058-7>.

[16] Yael Granot and others, 'In the Eyes of the Law: Perception versus Reality in Appraisals of Video Evidence.' (2018) 24 Psychology, Public Policy, and Law 93 <https://doi.apa.org/doi/10.1037/law0000137>.

[17] Cecelia Klingele, 'Notre Dame Law Review The Promises and Perils of Evidence-Based Corrections Recommended Citation' (2016) 91 Notre Dame Law Review <http://www.bjs.gov/con->. See also, Christopher Ansell and Robert Geyer, '"Pragmatic Complexity" a New Foundation for Moving beyond "Evidence-Based Policy Making"?' [2016] Policy Studies 1 <https://www.tandfonline.com/doi/full/10.1080/01442872.2016.1219033>.

[18] Yoni Fuadah Syukriani, Nita Novita and Deni K Sunjaya, 'Development of Forensic Medicine in Post Reform Indonesia' (2018) 58 Journal of Forensic and Legal Medicine 56 <https://linkinghub.elsevier.com/retrieve/pii/S1752928X1830252X>.

[19] Josua Sitompul, 'Improving the Role of Experts under Indonesian Criminal Procedure Law: Lessons Learned From the Dutch Legal System' (2018) 8 Indonesia Law Review 109 <https://scholarhub.ui.ac.id/ilrev/vol8/iss1/5>.

the emphasis on forensic science and its application in criminal cases was still in the nascent stages. The turn of the 19th to the 20th century witnessed a pivotal evolution in the criminal justice system, marking the birth of forensic science as an independent discipline.[20] Central to this transformation was Dr Edmond Locard,[21] who earned the moniker "Sherlock Holmes of Lyon" for his groundbreaking work.[22] In 1910, Locard inaugurated one of the earliest dedicated crime laboratories, firmly establishing himself at the forefront of this nascent field. One of Locard's seminal contributions was the Exchange Principle introduced in France. He posited that every interaction, however minor, leads to an exchange of material. This foundational idea, suggesting that no contact occurs without leaving a mark, became an integral part of modern forensic methodologies. Meanwhile, in a parallel development, the science of fingerprinting began to gain recognition.[23] Sir Francis Galton, through his exhaustive research, championed this method. He laid the groundwork for fingerprints to evolve from mere curiosities to indispensable tools in criminal investigations.[24] His rigorous studies and findings paved the way for the creation of organized fingerprint databases in the early 20th century, underscoring the growing trust in its reliability. Taken together, the pioneering efforts of individuals like Locard and Galton signaled a profound shift in the development of scientific knowledge.[25] Their work highlighted an era where empirical science began to weave itself intricately into the tapestry of criminal detection, serving as an enduring testament to the marriage of science and justice.

[20] Alison Adam, *A History of Forensic Science: British Beginnings in the Twentieth Century* (Routledge 2016). See also, Suzanne Bell and others, 'A Call for More Science in Forensic Science', *Proceedings of the National Academy of Sciences* (2018) <https://pnas.org/doi/full/10.1073/pnas.1712161115>.

[21] Dr. Edmond Locard (13 December 1877 – 4 May 1966) was a French criminologist, renowned as the pioneer in forensic science, earning him the moniker "the Sherlock Holmes of France". He formulated the fundamental principle of forensic science: "Every contact leaves a trace." This principle is now widely recognized as Locard's exchange principle.

[22] Gérard Labuschagne, *The Profiler Diaries: From the Case Files of a Police Psychologist* (Penguin Random House 2020). See also, Carrie Leonetti, 'The History of Forensic-Science Evidence in Criminal Trials and the Role of Early "Success" in Establishing Its Putative Reliability' (2023) 54 St. Mary's Law Journal <https://commons.stmarytx.edu/thestmaryslawjournal/vol54/iss4/5/>.

[23] John Berry and David A Stoney, 'History and Development of Fingerprinting' in Henry C Lee and RE Gaensslen (eds), *Advances in Fingerprint Technology* (second edition, CRC Press 2001).

[24] Howard A Harris and Henry C Lee, *Introduction to Forensic Science and Criminalistics* (CRC Press 2019) <https://www.taylorfrancis.com/books/9781498757980>.

[25] Robertson, Vignaux and Berger (n 9). See also, Jim Fraser, *Forensic Science: A Very Short Introduction* (Oxford University Press 2020).

**3. DNA and its Revolutionary Impact on Forensic Science**

In the realm of criminal forensics, the emergence and subsequent comprehensive understanding of DNA marked a transformative juncture.[26] The 1980s witnessed the blossoming of DNA's immense potential in forensic analysis, reshaping the very fabric of criminal investigation and providing tools of unprecedented accuracy.[27] At the forefront of this molecular revolution was Sir Alec Jeffreys,[28] whose innovative vision gave birth to the concept of DNA fingerprinting.[29] A technique that, for the first time, promised the ability to pinpoint individual identities with a degree of precision hitherto unimaginable. The true magnitude of this scientific leap was brought into sharp focus in 1986, during a landmark criminal case in England. The successful application of DNA evidence in this case sent ripples throughout the global legal community, ushering in a new era wherein judiciaries worldwide swiftly recognized and embraced DNA's unparalleled investigative prowess. However, like all pioneering ventures, this new chapter in forensics was not without its teething problems. The maiden voyage into DNA-based evidence revealed certain imperfections. Early techniques, although revolutionary, did not match the meticulous standards upheld today. As a result, several courtroom proceedings became battlegrounds of debates and controversies, casting shadows of doubt over the infallibility of DNA evidence.[30] It was not until the 1990s that a significant evolution in

[26] Manfred Kayser, 'Forensic Use of Y-Chromosome DNA: A General Overview' (2017) 136 Human Genetics 621 <http://link.springer.com/10.1007/s00439-017-1776-9>.

[27] Daniel S Medwed, *Wrongful Convictions and the DNA Revolution* (Cambridge University Press 2017).

[28] Sir Alec John Jeffreys, (born 9 January 1950), is a British geneticist renowned for developing techniques for genetic fingerprinting and DNA profiling, which are now utilized worldwide in forensic science to aid police detective work and to resolve paternity and immigration disputes. For DNA fingerprinting, technicians identify a person as the source of a biological sample by comparing the genetic information contained in the person's DNA to the DNA contained in the sample. Jeffreys developed the technique in the 1980s while at the University of Leicester in Leicester, UK. His technique had immediate applications. In forensic science, DNA fingerprinting enabled police to identify suspects of crimes based on their genetic identities. Previous biological techniques allowed only the exclusion of possible suspects, not the identification of individuals. Jeffreys' technique also enabled technicians to identify the father of a child in paternity testing.

[29] Usha Amulya Narem, 'DNA Profiling & Forensic Science: From Tracing Evolutionary Discoveries to the DNA Technology (Use & Application) Regulation Bill, 2018' (2019) 9 Supremo Amicus <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3986257>. See also, Kelly M Pyrek, *Pioneers in Forensic Science: Innovations and Issues in Practice* (CRC Press 2017).

[30] Helen Barrell, *Fatal Evidence: Professor Alfred Swaine Taylor & the Dawn of Forensic Science* (Pen and Sword History 2017). See also, Ronald J Allen and Christopher K Smiciklas, 'The Law's Aversion To Naked Statistics And Other Mistakes' (2022) 28 Legal Theory 179 <https://www.cambridge.org/core/product/identifier/S135232522200012X/type/journal_article>.

the domain of DNA forensics occurred. Enhanced by the introduction of state-of-the-art techniques, particularly PCR (Polymerase Chain Reaction) and STR (Short Tandem Repeat) analysis, the fidelity and reliability of DNA profiling witnessed considerable amplification.[31] These methodological advancements not only bolstered the credibility of DNA-based evidence but also firmly established DNA's role as an indispensable beacon in the ever-challenging quest for justice. This journey, from initial skepticism to widespread acceptance, underscores the adaptability and resilience of both the scientific and legal communities in their shared pursuit of truth

4. **Digital Age and the Rise of Cyber Forensics**

The latter decades of the 20th century and the dawn of the 21st witnessed an unprecedented digital revolution that reshaped societies at a foundational level.[32] With this profound shift toward a digital-centric world, where dependence on computers and electronic data repositories became the norm, a critical and complementary domain arose: cyber forensics.[33] Cyber forensics, or digital forensics as it's often termed, zeroes in on the meticulous extraction, preservation, and examination of electronic data.[34] As cybercrimes, electronic fraud, and other digital misdemeanors became more prevalent, this discipline's importance surged. From unearthing digital footprints left behind in cyber espionage to tracing intricate financial frauds, digital forensics plays a pivotal role in modern investigative procedures.[35] However, the digital landscape is in a perpetual state of flux, defined by rapid technological advancements. Consequently, digital forensics is equally dynamic. With every innovation, from enhanced encryption methods

[31] Akanksha Behl, Amarnath Mishra and Indresh Kumar Mishra, *Tools and Techniques Used in Forensic DNA Typing* (Springer 2021).

[32] Ewa Lechman, *The Diffusion of Information and Communication Technologies* (Routledge 2017).

[33] C Esposito and others, 'Esposito, C., Castiglione, A., Martini, B., & Choo, K. K. R. (2016). Cloud Manufacturing: Security, Privacy, and Forensic Concerns. IEEE Cloud Computing, 3(4)', (2016) 3 IEEE Cloud Computing.

[34] Amarantidou Pinelopi, 'Computer and Network Forensics: Investigating Network Traffic' (International Hellenic University 2017) <https://repository.ihu.edu.gr/xmlui/handle/11544/29161?show=full>. See also, Oludare Isaac Abiodun and others, 'Data Provenance for Cloud Forensic Investigations, Security, Challenges, Solutions and Future Perspectives: A Survey' (2022) 34 Journal of King Saud University - Computer and Information Sciences 10217 <https://linkinghub.elsevier.com/retrieve/pii/S131915782200369X>.

[35] Sundar Krishnan and Narasimha Shashidhar, 'Interplay of Digital Forensics in Ediscovery' (2021) 15 International Journal of Computer Science and Security (IJCSS) <https://www.cscjournals.org/manuscript/Journals/IJCSS/Volume15/Issue2/IJCSS-1602.pdf>.

to sophisticated malware, forensic tools and techniques must adapt, ensuring they remain a step ahead. These swift technological strides present a double-edged sword; they furnish forensic experts with cutting-edge tools while simultaneously posing fresh challenges, often in the form of ever-evolving cyber threats.

Throughout the annals of criminal science, the role of scientific evidence has undergone a remarkable transformation.[36] Historically, the deployment of such evidence in courts was rudimentary, typified by nascent frameworks that were yet to come of age. However, juxtapose that with today's landscape, and the shift is palpable. Contemporary methodologies have transitioned from basic models to profoundly nuanced and sophisticated approaches. Scientific evidence isn't merely a supplementary facet in legal discourse anymore; it has ascended to the forefront, becoming an indispensable instrument in shaping outcomes within the modern criminal justice milieu. This evolutionary journey underscores the profound influence of technological and scientific progress on the very sinews of legal mechanisms.[37] The strides taken in assorted scientific fields are reflected in the judiciary's heightened gravitation toward empirical data, championing just and precise verdicts.[38] The zenith of today's scientific endeavors, embodied in pioneering developments like DNA forensics and digital investigation, arms legal entities with tools of unmatched efficacy.[39] These instruments not only bolster the capacity to pinpoint offenders with acute accuracy but also serve to curtail judicial missteps, thereby fostering a more balanced legal journey for all stakeholders. The intricate dance between technological advancement and its reverberations within the legal corridors bears testimony to the system's innate adaptability and its earnest desire to evolve. As the relentless tide of science introduces avant-garde techniques and paradigms, the legal domain remains poised to reciprocate, ensuring that its protocols, statutes, and guidelines resonate harmoniously with the evolving epoch.

[36] Kraska, Brent and Neuman (n 10).

[37] Anton de Waal Alberts, 'The Degree of the Lack of Regulation of Space Debris Within the Current Space Law Regime and Suggestions for a Prospective Legal Framework and Technological Interventions' in Annette Froehlich (ed), *Space Security and Legal Aspects of Active Debris Removal* (2019) <https://link.springer.com/10.1007/978-3-319-90338-5_6>.

[38] Johann August Koehler, 'Making Crime a Science: The Rise of Evidence-Based Criminal Justice Policy' (University of California, Berkeley 2019).

[39] Machado and Granja (n 11).

**The Theoretical Framework Surrounding Scientific Evidence in Criminal Law**

Scientific evidence within criminal law operates within a complex, ever-evolving theoretical framework. This framework has developed over centuries, reflecting the intersections of epistemology, jurisprudence, and scientific methodology.[40] At its essence, this theory underscores the value of objective, quantifiable, and replicable evidence over mere subjective accounts. The following elaborates on the intricacies of this framework, its historical development, and its relevance in the contemporary legal landscape.

**1. Historical Context**

Historically, legal frameworks largely depended on subjective narratives, primarily eyewitness testimonies and personal accounts.[41] Yet, as the broader societal landscape underwent a transformation due to the scientific revolution, a parallel shift began to emerge in the judicial realm. The appeal of basing judgments on empirical, tangible evidence became increasingly evident.[42] However, this transformation was neither swift nor embraced by all. A mounting skepticism toward the unreliability and inconsistencies inherent in human memory and perception paved the way for this change. People began to question the authenticity and accuracy of mere recollections, especially when juxtaposed with the precision and objectivity that science promised. As faith in subjective accounts waned, the conviction grew that science could usher in a new era of clarity and definitive truths in the legal sphere.

**2. Objective over Subjective**

The predilection for objective evidence over subjective accounts within the legal framework is firmly grounded in the inherent limitations of human cognition.[43] While eyewitness testimonies have their value, they are notably susceptible to

[40] Brian G Sellers and Bruce A Arrigo, 'The Narrative Framework of Psychological Jurisprudence: Virtue Ethics as Criminal Justice Practice' (2022) 63 Aggression and Violent Behavior 101671 <https://linkinghub.elsevier.com/retrieve/pii/S1359178921001257>.

[41] Chris Heffer, 'Narrative in the Trial: Constructing Crime Stories in Court', *The Routledge Handbook of Forensic Linguistics* (2nd Edition, Routledge 2020).

[42] D Kim Rossmo, 'Case Rethinking: A Protocol for Reviewing Criminal Investigations' (2016) 17 Police Practice and Research 212 <https://www.tandfonline.com/doi/full/10.1080/15614263.2014.978320>.

[43] Marko Milanovic, 'Establishing the Facts About Mass Atrocities: Accounting for the Failure of the ICTY to Persuade Target Audiences' [2016] Georgetown Journal of International Law, Forthcoming <https://ssrn.com/abstract=2757151>.

an array of cognitive biases that can distort the truth.[44] These biases encompass a spectrum, ranging from the natural tendency of individuals to misremember critical details, to the pernicious effects of external influences, like media reports or peer pressure. Human memory is far from the infallible recorder it is often perceived to be. It can easily warp and change over time, influenced by factors that were not initially present in the memory.[45] A witness might unknowingly fill in gaps in their memory with fabricated details, thinking them to be true.[46] This malleability makes eyewitness accounts, though valuable, a somewhat unreliable basis for judicial decisions. In stark contrast, scientific evidence, by its very nature, is less susceptible to these cognitive pitfalls. It stands as an unflinching testament to empirical truths. Consider the example of DNA evidence: it doesn't "remember" or "misremember"; it presents a constant and objective account of the facts. The same holds true for various other forms of scientific evidence, spanning the realms of toxicology, ballistics, and digital forensics.[47] These are based on concrete data and precise measurements, rather than human interpretations that are vulnerable to bias. In a world where the reliability and fairness of legal verdicts are paramount, the objective nature of scientific evidence becomes indispensable.[48] It helps to reduce the influence of human error and bias, thereby offering a more robust foundation for justice. It is, in essence, a quest for a truth that remains unaffected by the frailties of human perception and memory, guided instead by the unyielding principles of scientific rigor and objectivity.

[44] Steve Charman, Amy Bradfield and Alexis Mook, 'Cognitive Bias in Legal Decision Making' [2019] Psychological science and the law. See also, Carla Maclean, Lynn Smith and Itiel Dror, 'Experts on Trial: Unearthing Bias in Scientific Evidence' (2020) 53 University of British Columbia law review.

[45] Gary Edmond and Kristy A Martire, 'Just Cognition: Scientific Research on Bias and Some Implications for Legal Procedure and Decision - Making' (2019) 82 The Modern Law Review 633 <https://onlinelibrary.wiley.com/doi/10.1111/1468-2230.12424>.

[46] Dr Brent A Paterline, 'Forensic Hypnosis and the Courts' (2016) 4 Journal of Law and Criminal Justice <http://jlcjnet.com/vol-4-no-2-december-2016-abstract-1-jlcj>.

[47] Shipra Gupta and Indu Bharti Jain, 'Crime Scene Investigation And Forensic Evidence: Forensic Analysis And Tools' (2023) 14 Journal of Pharmaceutical Negative Results. See also, Mike Illes and Paul Wilson, *The Scientific Method in Forensic Science: A Canadian Handbook* (Canadian Scholars' Press 2020).

[48] C Nesson, 'The Evidence or the Event? On Judicial Proof and the Acceptability of Verdicts' in Scott Brewer (ed), *Logic, Probability, and Presumptions in Legal Reasoning* (Routledge 2013). See also, Amina Memon, Aldert Vrij and Ray Bull, *Psychology and Law: Truthfulness, Accuracy and Credibility* (John Wiley & Sons 2003).

### 3. Challenges and Debates: Scientific Evidence in the Legal Sphere

While scientific evidence has paved a transformative path in the legal realm, its integration is not without complexities and challenges. The development of breakthroughs in the field of scientific knowledge has a significant impact on the functioning of scientific evidence. One of the salient challenges lies in interpretation. It's a misconception to believe that even the most concrete scientific evidence speaks for itself in court.[49] Instead, it often demands expert interpretation, which can introduce a level of subjectivity. Numerous cases have seen experts, armed with the same dataset, arrive at contrasting conclusions.[50] This divergence is not merely about reading the data but also about the methodologies applied, the nuances in laboratory practices, and even differences in foundational training and philosophy. Additionally, the aura of infallibility surrounding scientific evidence requires scrutiny.[51] While it's undeniable that such evidence, in many instances, offers a level of reliability surpassing subjective accounts, it's far from immune to errors. Issues ranging from inadvertent laboratory mistakes to the more serious, albeit rarer, deliberate evidence tampering, can undermine its credibility.[52] The specter of cross-contamination further complicates matters, occasionally leading to misleading or wholly erroneous conclusions. This landscape of potential pitfalls emphasizes the criticality of strict protocols and rigorous oversight within forensic laboratories.[53] It's about fostering a culture of precision and ensuring continuous checks and balances. The objective is not merely about harnessing the power of science but ensuring its judicious and ethical application in the pursuit of justice.

[49] Robertson, Vignaux and Berger (n 9).

[50] CNN Editorial Research, 'Casey Anthony Trial Fast Facts' (*edition.cnn.com*, 2022) <https://edition.cnn.com/2013/11/04/us/casey-anthony-trial-fast-facts/index.html>, Tim Ott, 'Amanda Knox: A Complete Timeline of Her Italian Murder Case and Trial' (*biography.com*, 2007) <https://www.biography.com/crime/amanda-knox-murder-trial-timeline-facts>, cnnindonesia, 'Netizen Kembali Soroti Kasus Jessica Wongso Usai Lihat Ice Cold' (*cnnindonesia.com*, 2023) <https://www.cnnindonesia.com/hiburan/20231003141548-220-1006558/netizen-kembali-soroti-kasus-jessica-wongso-usai-lihat-ice-cold>.

[51] Zach Alter, 'Unpacking Frye-Mack: A Critical Analysis of Minnesota's Frye-Mack Standard for Admitting Scientific Evidence' (2017) 43 Mitchell Hamline Law Review <https://open.mitchellhamline.edu/cgi/viewcontent.cgi?article=1081&context=mhlr>.

[52] DK Bakardjiev, 'Officer Body-Worn Cameras-Capturing Objective Evidence with Quality Technology and Focused Policies' (2015) 56 Jurimetrics.

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The relationship between scientific evidence and criminal law is highly complex. It not only pertains to profound philosophical principles concerning the nature of truth and knowledge but is also fundamental for parties seeking justice through a scientific evidence approach. Although the framework of scientific evidence has evolved with technological advancements and changes in societal values, the core principles of scientific evidence remain consistent: objective, replicable, and measurable evidence serves as the foundation for the realization of justice, as opposed to relying solely on eyewitness testimony.

**4. Scientific Evidence within the Framework of Indonesian Criminal Law**

Scientific evidence plays a crucial role within the framework of Indonesian criminal law, notably governed by Article 184 of the Indonesian Criminal Procedure Code (KUHAP) and the legislation encompassed in Law No. 11 of 2008 on Information and Electronic Transactions, as amended by Law No. 19 of 2016, and further revised by Law No. 1 of 2024 on the Second Amendment to Law No. 11 of 2008 on Information and Electronic Transactions. Article 184 of the KUHAP addresses the admissibility of expert testimony in court proceedings. It explicitly acknowledges the value of expert opinions, emphasizing their importance in assisting the judiciary to comprehend complex technical or scientific matters. This provision underscores the integration of scientific expertise into the legal process, ensuring a more informed and objective assessment of evidence. Additionally, the Information and Electronic Transactions Law (UU ITE) reflects the adaptation of legal frameworks to contemporary challenges posed by the digital era. This legislation encompasses various provisions that may require the presentation and consideration of scientific evidence, particularly in cases involving cybercrimes and electronic transactions. The nature of offenses covered by the UU ITE often necessitates the expertise of forensic analysts and digital experts, highlighting the expanding role of scientific evidence in addressing modern legal challenges. These legal provisions illustrate a paradigm shift toward a more comprehensive and sophisticated understanding of evidence within the Indonesian legal context. The theoretical framework surrounding scientific evidence, as reflected in Article 184 of the KUHAP and the Information and Electronic Transactions Law, exemplifies Indonesia's commitment

to embracing advancements in forensic science and technology, thereby enhancing the effectiveness and fairness of its criminal justice system.

## Conclusion

The evolution of scientific evidence has shifted the conventional paradigm that solving crimes merely requires eyewitness testimony, which holds a high potential for bias. Instead, the investigative process has transformed to be based on scientific evidence that is verifiable and possesses high validity. This shift aims to uncover truth and uphold justice through a rigorous and objective approach. This includes the evolution of DNA evidence to cyber evidence in the field of information technology. Within the theoretical framework, scientific proof is based on evidence that is objective, replicable, and measurable. This provides a stronger foundation for achieving truth and justice compared to mere factual testimony. The seamless integration of scientific evidence in modern criminal law underscores a commitment to upholding justice, ensuring that verdicts are not just swift but also fair, balanced, and rooted in objective truth.

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