How do Lawyers relate to Science Literacy? A New Methodological Framework

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INTRODUCTION

Science helps the law to understand the world in which law and legal policy must operate.[2] Yet, it is widely recognised that law and science approach the world in different ways: law must provide finality and stability, whereas science is encouraged to embrace new ideas so that we can better understand the natural world.[3] The criminal justice system's use of forensic science identification techniques, like tool-mark, bite-mark and fingerprint analysis, illustrate how these differences can have challenging consequences: law can misuse science, be sceptical about change, and place a narrow construction on what is rational.[4] These approaches can contribute to wrongful convictions[5] and be exacerbated by lawyers having limited options for science education and training.[6]

Identifying strategies to enhance these education and training options is important because of the competencies associated with lawyering. Lawyers make key calls about scientific evidence at all stages of its journey through the criminal justice system — its selection, how it is presented and challenged, and how it will inform case strategy. Moreover, lawyers can become judges, who then make other key decisions, for instance about what precedent to follow or shape regarding admissibility, the boundaries of direct and cross-examination of expert witnesses, and the tools lawyers can use in both pursuits.[7] The concept of *science literacy*[8] — the "knowledge and disposition needed to engage with science"[9] — is relevant to these competencies, and, this paper proposes that understanding how lawyers relate to this concept, in terms of how it is relevant and useful to their practice, could inform the development of more meaningful science training and education packages. However, as reported by the National Academy of Sciences, "the value of science literacy in the …justice system… [including] opportunities [that system] provides to develop science literacy…[has] not been studied in sufficient detail."[10] There is, however, a diverse portfolio of research focused on science literacy in other spaces, including in schools, families, and neighborhoods,[11] to learn from.

This portfolio speaks readily to legal practice and can serve as a roadmap for researchers interested in science literacy and the law. This includes in its explicit call for more research about science literacy relating to the justice system,[12] but also in other, more subtle ways. A few examples, starting with two of the accepted rationales for why science literacy is "important and necessary."[13] The

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[2] DAVID L. FAIGMAN, LEGAL ALCHEMY: THE USE AND MISUSE OF SCIENCE IN THE LAW 26 (1999). Faigman states "without [science], legal policy is literally blinded." *Id*.

[3] Sarah L. Cooper, *The Collision of Law and Science: American Court Responses to Developments in Forensic Science*, 33 PACE L. REV. 234, 300 (2013) ("[L]aw must serve as a way of organizing societies by providing stability and predictability, whereas science is encouraged to embrace new ideas so that we can better understand the natural world.").

[4] Sarah L. Cooper, *Forensic Science Identification Evidence: Tensions Between Law and Science*, 16 J. PHIL. SCI. L. 1 (2016).

[5] *Id* at 3.

[6] THE COMM. ON IDENTIFYING THE NEEDS OF THE FORENSIC SCI. CMTY., NAT'L ACADS., STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD, 26-28 (National Academies Press, 2009) [hereinafter *Strengthening*] ((summarising the Committee's findings regarding "Insufficient Education and Training").

[7] Sarah L. Cooper & Amelia Shooter, *A Case for Conceptualizing Science Literacy for Lawyers,* 13 AM. U. CRIM. L. PRAC. 5-6 (2022).

[8] In line with common practice, in this paper, the author uses the term "science literacy" as an umbrella term that also encapsulates "technology literacy." COMM. ON SCIENCE LITERACY AND PUB. PERCEPTION OF SCIENCE, SCIENCE LITERACY: CONCEPTS, CONTEXTS, AND CONSEQUENCES 31-33 (Nat'l Acads. Press 2016) [hereinafter *Science Literacy*].

[9] *Id* at 27.

[10] *Id* at 110.

[11] See, *Science Literacy* at *supra* note 8, generally.

[12] *Id* at 110.

[13] *Id* at 22. The other two rationales, discussed *infra*, are the economic rationale and the cultural rationale.

personal rationale, for instance, argues that science literacy allows people to better "respond to issues and challenges that emerge in their personal and community contexts."[14] An understanding of science can help us make better choices regarding our health, for example. This advantage could easily extend to professional pursuits, especially for lawyers operating in a public interest space like the United States (US) criminal justice system, where research has found that law students go on to "sustain a more proximate conception of professional identity, overlapping with racial, gender, political, and other centrally constitutive roles"[15] in their lives. Further, the democratic rationale contends science literacy promotes better participation in civic decision making around major societal challenges, like preventing disease and environmental protection.[16] Again, staying with the example of lawyers working in the US criminal justice system, considering the known scale of error,[17] the prevention of wrongful conviction could be described as such a challenge. Indeed, the National Registry of Exonerations has commented that it is "impossible to fully grasp the magnitude of the injustice and suffering."[18] There is also a sense of familiarity, for lawyers, with certain operational criteria proposed to test the extent to which a person is science literate. For instance, criteria developed by Fourez includes being able to know the "right use"[19] of "specialists"[20] and "Black Boxes" (globally accepted representations of the world).[21] These phrases, respectively, chime neatly with common legal practices, like the selection of experts and taking of "judicial notice."[22] Furthermore, there are identities, prioritized within the portfolio, that are relatable to lawyers. For example, there is a keenness to investigate science literacy within communities with "shared routines, activities, and goals."[23] Lawyers group like this in various spaces, for instance in law schools, law offices and professional networks. Furthermore, lawyers speak strongly to Feinstein's notion of the "*competent outsider*"[24] – a person who is "anchored outside of science, reaching in for bits and pieces that enrich their understanding of their own lives."[25]

Harnessing this work and drawing on intersections between criminal justice and forensic science techniques for context, this paper presents a new methodological framework for investigating how lawyers relate to the concept of science literacy. Part I sets the scene for the new framework, describing how law and science intersect generally and then specifically in terms of the US criminal justice system's use of forensic science techniques. It then explains how uncertainty at that intersection, catalysed by scientific progress around DNA evidence, has been addressed (guardedly) by criminal courts in ways that illuminate the different approaches law and science take to the world. Part II defines science literacy and maps its relevance to legal practice and concerns about lawyers' scientific expertise in the context of criminal justice and forensics, making the case for why a new framework for investigating how lawyers relate to science literacy, in the context of legal practice, could help to reconcile those differences. Part III presents the framework, which harnesses the National Academy of Sciences' conceptualisation of science literacy, and its call for research that focuses on societal systems, community structures, and the relevance of science literacy to daily life.

PART I: LAW, SCIENCE AND CRIMINAL JUSTICE

Science and technology provide law with a range of facts relevant to legal practice.[26] They can tell law enforcement someone's last known location based on cell phone data, whether illegal images

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[14] *Id* at 24.
[15] See, John Bliss, *Divided Selves: Professonal Role Distancing Among Law Students and New Lawyers in a Period of Market Crisis*, 42(3) J. AM. BAR FOUND. 855 (2017).
[16] *Science Literacy, supra* note 8, at 25.
[17] See, generally, The National Registry of Exonerations, https://www.law.umich.edu/special/exoneration/Pages/about.aspx (last visited .
[18] National Registry of Exonerations, Milestone: Exonerated Defendants Spent 20,000 Years in Prison (2018). See, Microsoft Word - NRE.20,000Yrs.Report.8.30.18.Final.docx (umich.edu)
[19] Gerrard Fourez, *Scientific and Technological Literacy as Social Practice*, 27(6) SOC. STUD. SCI. 903, 911 (1997).
[20] *Id*.
[21] *Id* at 912.
[22] See, *Judicial* Notice, Merriam-Webster.com Dictionary, Merriam-Webster, https://www.merriam-webster.com/legal/judicial%20notice (last visited.
[23] *Science Literacy, supra* note 8, at 74.
[24] Noah W. Feinstein, *Salvaging Science Literacy*, 95(1) Sci. Educ. 168, 180-181(2011).
[25] *Id* at 180.
[26] Cooper, *supra* note 3, at 237.

are stored on a computer cloud, or if someone was driving whilst unlawfully intoxicated. They can help resolve litigation, for example, by confirming who fathered a child involved in divorce proceedings, or whether an injury is a known side-effect of a vaccine in a matter before the Vaccine Court. They can inform legal policy too. For example, climate science can help lawmakers to shape appropriate environmental protection regulations, and neuroscience can help legislators determine an appropriate age for criminal responsibility and juvenile transfer to adult criminal court.

Noting those examples, a familiar intersection between law and science, to many, will be the criminal justice system's use of an array of forensic science identification techniques, like fingerprint, tool-mark, bite-mark, hair, shoe, and tire print analysis, to help solve crime. This sort of evidence has long been embraced by the US criminal justice system, as recognized by the National Academy of Sciences (NAS) in its landmark 2009 report, *Strengthening Forensic Science in the United States: A Path Forward*:

> "For decades, the forensic science disciplines have produced valuable evidence that has contributed to the successful prosecution and conviction of criminals … Many crimes that may have gone unsolved are now being solved because forensic science is helping to identify the perpetrators."[27]

However, *Strengthening* also recognised a building tension at this intersection, namely that scientific advances had revealed uncertainty and error in what had gone before. Science had powered forward and produced DNA techniques that could provide unrivalled consistency and degrees of certainty in terms of connecting suspect evidence to individual sources.[28] In doing so, science had served the criminal justice system by finding ways to, more reliably, exonerate the innocent and inculpate the guilty, but also shook it. These advances questioned those other, long-used forensic techniques[29] and confirmed the criminal justice system was vulnerable to error. On that, the National Registry of Exonerations reports that 25% of its currently recorded 3400+ exonerations relate to "False or Misleading Forensic Evidence."[30] As the NAS described in *Strengthening*, the criminal justice system had provided a space for "faulty forensic science analyses,"[31] undue weight to be given to evidence and testimony "derived from imperfect testing and analysis"[32] and the admission of "erroneous or misleading evidence"[33] and "imprecise or exaggerated expert testimony."[34]

Strengthening catalysed a wave of nationwide responses. The American Academy of Forensic Sciences issued a supporting statement.[35] In 2013, the Department of Justice, in partnership with the National Institute of Standards and Technology, established the National Commission on Forensic Science as a Federal Advisory Committee.[36] In 2014, the Organization of Scientific Area Committees (OSAC) for Forensic Science was created by the National Institute of Scientific Standards.[37] The President's Council on Advisors on Science and Technology produced a follow-up report in 2016.[38] Various collaborative partnerships between stakeholders formed.[39] By 2018, it was reported the

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[27] *Strengthening*, *supra* note 6 at 4.
[28] *Id* at 7 ("With the exception of nuclear DNA analysis, however, no forensic method has 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.")
[29] Cooper, *supra* note 3 at 235-6.
[30] See, The National Registry of Exonerations, *Exonerations Contributing Factors by Crime*, THE NATIONAL REGISTRY OF EXONERATIONS,https://www.law.umich.edu/special/exoneration/Pages/ExonerationsContribFactorsByCrime.aspx.
[31] *Id* at 4.
[32] *Id*.
[33] *Id*.
[34] *Id*.
[35] See, American Academy of Forensic Sciences, *Responses to the National Academy of Sciences "Forensic Needs" Report*, AM. ACAD. FORENSIC SCI., https://www.aafs.org/article/response-national-academy-sciences-forensic-needs-report.
[36] See, U.S. Dep't Just., *National Commission on Forensic Science*, U.S. DEP'T JUST., https://www.justice.gov/archives/ncfs.
[37] NIST Launches an Updated Organization of Scientific Area Committees for Forensic Science (Oct. 1, 2020), https://www.nist.gov/news-events/news/2020/10/nist-launches-updated-organization-scientific-area-committees-forensic (last visited Dec. 20, 2022).
[38] Executive Office of the President, President's Council of Advisors on Sci. and Tech., Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature Comparison Methods (Executive Office of the President of the United States 2016) (hereinafter, PCAST).
[39] For example, the Innocence Project, the National Association for Criminal Defense Lawyers and Winston & Strawn LLP, announced a partnership with the Federal Bureau of Investigation and the Department of Justice to review nearly 3,000 criminal cases in which microscopic hair analysis conducted by the FBI was used to inculpate the defendant(s). See, Innocence Project, *FBI Testimony on Microscopic Hair Analysis*

National Institute of Justice had invested over £123 million on grants to "address the research needs outlined in [*Strengthening*]."[40] Now it is considered some forensic techniques, like fingerprinting and firearms analysis, can report stronger cases for validity,[41] and other disciplines, like bite-mark analysis have attracted further concern.[42] As Neufeld comments, "the progress [*Strengthening*] set in motion cannot be understated—it is not an exaggeration to say that the report has freed innocent people and saved lives."[43] In 2023, marking the fifteen-year anniversary of *Strengthening*, the *Journal of Forensic Sciences* summarised there had been progress in meeting the report's challenges but also that "there is much still to do,"[44] signalling that the situation will, naturally, evolve as we continue to learn more about relevant forensic techniques.

An evolving situation, though, is not necessarily a comfortable one for law, especially the criminal justice system. Notwithstanding the responses mentioned above, the judicial system at federal and state level has generally been reluctant to change its ways to account for the uncertainty presented in *Strengthening*.[45] This is not surprising because law has a different 'job' to science: law must provide finality and predictability to stabilize society, whereas science is encouraged to embrace new ideas so that we can better understand the natural world.[46] Shooter's work helps us to understand the how and why of this judicial response. After reviewing over 600 appellate cases in criminal proceedings citing the NAS' forensic science report portfolio, including *Strengthening*, Shooter's headline finding was that judicial responses are characterised by "fidelity to the legal process vision"[47] not a scientific perspective, chiming, on a large scale, with previous analyses of such case law.[48] In manifesting loyalty to this vision, Shooter concluded courts prioritize four practices. First, following precedent, which sees courts looking backwards for future direction. This can result in "law struggling to update in response to scientific progress."[49] Second, deferring widely to decisions made by trial court agents – trial judges, lawyers, experts, and jurors – within the scope of their competencies i.e., a valuing of institutional settlement. This can, however, through overly focusing on procedure "preclude a review of substantive scientific claims."[50] Three, pursuing finality through relying on high legal standards and institutional settlement, which can, again, neglect a "substantive examination"[51] of claims relating to scientific uncertainty.[52] Four, assuming rationality in trial court proceedings, notwithstanding that science, in the form of the NAS reports for instance, might suggest otherwise.[53]

These practices are embedded within the fabric of law and legal practice. And it is in *this* holistic practice that the "uneasy alliance"[54] between science and law, how they "exist in two different

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Contained Errors in at least 90% of Cases in Ongoing Review, INNOCENCE PROJECT, https://innocenceproject.org/fbi-testimony-on-microscopic-hair-analysis-contained-errors-in-at-least-90-of-cases-in-ongoing-review/.

[40] See, Innocence Project, *Ten Years Later: The Lasting Impact of the 2009 NAS Report*, INNOCENCE PROJECT, https://innocenceproject.org/lasting-impact-of-2009-nas-report/ [hereinafter *Ten Years Later*].

[41] *Id*. (This investment has yielded evidence that advanced some forensic science disciplines from their status as 'reviewed by the NAS report in 2009' to 'improved levels of validity….[it has been concluded] that latent print comparison had achieved foundational validity and that firearm comparisons had taken strong steps toward achieving that status")

[42] PCAST, *supra* note 38 at 87 ("PCAST considers the prospects of developing bitemark analysis into a scientifically valid method to be low. We advise against devoting significant resources to such efforts.") Note states have taken actions reflecting this position too. For example, in 2016, the Texas Forensic Science Commission recommended a moratorium on the use of bite mark evidence. See, Innocence Project, *In an Landmark Decision, Texas Forensic Science Commission Issues Moratorium on the use of Bite Mark Evidence*, INNOCENCE PROJECT, https://innocenceproject.org/in-a-landmark-decision-texas-forensic-science-commission-issues-moratorium-on-the-use-of-bite-mark-evidence/ Subsequently, Texas courts can be seen to treat such evidence cautiously. See, e.g., Ex Parte Chaney, 563 S.W.3d 239 (2018).

[43] See, *Ten Years Later*, *supra* note 40.

[44] See, Journal of Forensic Sciences, *The Path Forward – Forensic Sciences Response to the National Academies of Sciences Report 2009*, WILEY ONLINE LIBRARY, https://onlinelibrary.wiley.com/doi/toc/10.1111/(ISSN)1556-4029.the-path-forward.

[45] See., e.g., Cooper, supra note 3; Sarah L. Cooper, *Judicial Responses to Shifting Scientific Opinion in Forensic Identification Evidence and Newly Discovered Evidence Claims in the United States: The Influence of Finality and Legal Process Theory*, 4 BRIT. J. AM. LEG. STUD. 649 (2015); Sarah L. Cooper, *Judicial Responses to Challenges to Firearms Identification Evidence: A Need for New Judicial Perspectives on Finality*, 31 T.M. COOLEY L. REV. 457 (2014). Also see, generally, Amelia Shooter, 100 Years of the National Research Council: A Critical Examination of Judicial References to Forensic Science NAS Reports (Nov. 2019) (Ph.D. thesis, Birmingham City University).

[46] Cooper, *supra* note 3, at 237.

[47] Shooter, *supra* note 45, at 7.

[48] See, generally, Cooper, *supra* note 45. Also see, Cooper, *supra* note 4.

[49] Shooter, *supra* note 45, at 299.

[50] *Id*.

[51] *Id*.

[52] *Id*.

[53] *Id*.

[54] See, *Strengthening*, *supra* note 6 at 86.

worlds with contradictory principles and paradigms,"[55] is brought into sharp focus. Law seeks to resolve disputes in a way that is "final, just and socially acceptable,"[56] whereas science is concerned with verifiable facts ascertained through empirical analysis[57] and describing the universe as it is, not what it should be.[58] As Faigman summarizes:

> "[s]cience progresses while law builds slowly on precedent. Science assumes that humankind is determined by some combination of nature and nurture, while law assumes that humankind can transcend these influences and exercise free will. Science is a cooperative endeavor, while most legal institutions operate on an adversary model."[59]

As Jasanoff explains, "The use of scientific evidence…in court…brings into collaboration two institutions with significantly different aims and normative commitments."[60] The criminal justice system is a space where neither science nor law completely retains or completely relinquishes its autonomy.[61] In courtrooms, law cannot "fully bend to science's pace and manner of truth production"[62] and science cannot "proceed in quite the same ways as science done purely to advance the cause of science."[63] This picture sets the scene for the new methodological framework by prompting the question: how can we reconcile these differences in pursuit of a stronger justice system? Part II suggests a strategy, namely focusing on science literacy in the context of legal practice.

PART II: SCIENCE LITERACY AND LEGAL PRACTICE

Coined in the late 1950s, the phrase 'science literacy' has "defied precise definition"[64] although it is widely recognized to be a "desired outcome of science education."[65] Since then, the meaning of science literacy – what it means to be science literate – has been the subject of a wide-ranging discussion, although, unsurprisingly, education features quite heavily.[66]

A *precis* of this discussion is helpful to foreground the connection between science literacy and legal practice. In the late 1950s, against the backdrop of post-WWII scientific advancements, Hurd and the Rockefeller Report, defined science literacy "as knowledge of science and the scientific enterprise, especially in the context of science's newly acquired strategic importance in society."[67] This social context of science was promoted in the 1970s. The National Science Teachers Association, for example, took the position that science literacy meant a person could use "science concepts, process skills, and values in making everyday decisions"[68] when they interact with others and their environment, and that they understood "the interrelationships between science, technology and other facets of society, including social and economic development."[69] In the 1990s, the National Academy of Sciences co-ordinated development of the *National Science Education Standards*, offering science literacy meant a series of more specific abilities, including being able to ask and determine answers to questions derived from everyday curiosities; describe, explain, and predict natural phenomena; read about popular science with understanding and engage in social conversations about validity; identify scientific issues and

[55] See, *Ten Years Later*, *supra* note 40 (quoting Peter Neufeld).
[56] See, *Strengthening*, *supra* note 6 at 86.
[57] *Id*.
[58] *Id*.
[59] Faigman, *supra* note 2, at 56.
[60] Sheila Jasanoff, *Just Evidence: The Limits of Science in the Legal Process*, 34 J.L. MED. & ETHICS 328, 329 (2006).
[61] *Id*.
[62] Jennifer E. Laurin, *Criminal Law's Science Lag: How Criminal Justice Meets Changed Scientific Understanding*, 93 TEX. L. REV. 1751, 1753 (2015).
[63] Jasanoff, *supra* note 60, at 329.
[64] George E. DeBoer, *Scientific Literacy: Another Look at its Historical and Contemporary Meanings and its Relationship to Science Education Reform*, 37(6) J. RSCH. SCI. TEACHING 582 (2000).
[65] *Id*.
[66] See, *Science Literacy* at *supra* note 8, generally.
[67] *Id* at 587.
[68] National Science Teachers Association, NSTA position statement on school science education for the 70's. The Science Teacher, 38, 46- 51 at pp. 47- 48. DeBoer, *supra* note 64, at 588.
[69] *Id*.

express informed positions; evaluate the quality of science based on source and method; and pose and evaluate arguments based on evidence.[70] In 1997, Fourez proposed that science literacy was about empowerment,[71] a state whereby a person has knowledge that gives them a certain autonomy, capacity to communicate, and "practical ways of coping with specific situations and negotiating over outcomes."[72] Science literacy, therefore, concerned a person's material environment and their emotional, social, ethical and cultural situations.[73] At the start of the new millennium, Deboer summarised that science literacy referred to a "[d]esired familiarity with science…what the public should know to live more effectively with respect to the natural world,"[74] and Norris *et al* focused on there being a "fundamental sense of scientific literacy",[75] namely reading and writing about scientific content (which they argued should be prioritised), and a "derived sense"[76], that is being knowledgeable, learned, and educated in science.[77] In 2010, Feinstein reflected that, when coined in the 1950s, 'science literacy' merely provided "a new label for the well-established notion that some mastery of science is essential preparation for modern life"[78] and suggested focus should be on its "usefulness in daily life."[79]

Over time, conceptualisations of 'science literacy'– and the reasons for having it – have emerged.[80] In 2016, the National Academy of Sciences carried out a systematic review and landed on there being four rationales why science literacy is "important and necessary."[81] These are the economic rationale (a science-literate nation can power economic prosperity),[82] the personal rationale (science literacy can help people to respond to issues and challenges in their own lives),[83] the democratic rationale (a democracy performs better when people are informed in their civic decision-making, especially about major societal challenges),[84] and the cultural rationale (science is some of the "best worth knowing,"[85] an important cultural activity and powerful way of understanding the world).[86] The NAS also conceptualised science literacy in seven dimensions that represented "a sort of theoretical common ground."[87] These dimensions are *foundational literacies* (concepts, skills, understandings, and values generalizable to interpreting texts, like numeracy, textual literacy, understanding graphs etc);[88] *content knowledge (*understanding a set of scientific terms, concepts, and facts);[89] *understanding of scientific practices* (how scientists do science, the ability to design and evaluate scientific inquiry);[90] *Identifying and Judging Appropriate Scientific Expertise* (the ability to judge a scientist's expertise, based on things like publications, grants, and training);[91] *epistemic knowledge* (understanding how the procedures of science support claims);[92] *cultural understanding of science* (understanding the achievement and wonder of science);[93] and *dispositions and habits of mind* (certain characteristics, like open-mindedness, may help foreground other skills and knowledge required).[94]

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[70] *Id* at 590. National Research Council (1996). National Science Education Standards. Washington, DC: National Academy Press at 1-2.
[71] Fourez, supra note 19, at 906. ("The concept of scientific and technological literacy therefore refers to a degree of empowerment of the individual, not to some definitely acquired and specific skill.")
[72] *Id*.
[73] *Id*.
[74] See DeBoer, *supra* note 64, at 582.
[75] Stephen P. Norris & Linda M. Phillips,(2003), *How Literacy in its Fundamental Sense is Central to Scientific Literacy*,87(2) SCI. ED., 224 (2003)..
[76] *Id*.
[77] *Id*.
[78] Feinstein, *supra* note 24, at 168.
[79] *Id* at 173.
[80] For example, Norris *et al*, *supra* note 75, at 225-226.
[81] *Science Literacy, supra* note 8, at 22.
[82] *Id* at 23-24.
[83] *Id* at 24.
[84] *Id* at 25.
[85] *Id* (citing Spencer, H. (1884). *What Knowledge Is of Most Worth*. New York: JB Alden.)
[86] *Id* at 25-26.
[87] *Id* at 32.
[88] *Id*.
[89] *Id*.
[90] *Id* at 32-33.
[91] *Id* at 33.
[92] *Id*.
[93] *Id*.
[94] *Id*.

Considering the above, the *prima facie* relevance of science literacy to legal practice, and to lawyers specifically, is palpable. It's more than a surface connection, though. The necessity of science literacy in legal practice has long been recognized across various legal issues, including education, technology, the environment and public health, consumer choices, and, indeed, criminal justice and forensic science.[95] As Faigman and Lesikar, write "[t]he process of translating scientific knowledge for legal use requires some degree of scientific literacy *and* an understanding of the sum and substance of the law…."[96] A lawyer must find ways to build and bridge these knowledge bases and skills, and if we assume lawyers have the necessary toolkit for the legal side of this task then, focus should land on building their science toolkit.

There are several reasons why finding ways to build this toolkit is important. First, it is critical because lawyers' competencies map to the NAS' concept of science literacy i.e., lawyers need the dimensions of science literacy to do the things they are required to do. If we look at, for example, key legal competencies in criminal proceedings involving forensic evidence, this becomes clear.[97] In line with their monopoly on case strategy, lawyers make decisions about whether expert evidence is needed, and, if so, which expert(s) to engage (*Identifying and Judging Appropriate Scientific Expertise).* If expert evidence is deemed admissible, lawyers will decide how it is presented on behalf of their party at trial, through managing direct-examination. Through questioning strategies, this might include having an expert explain numerical and graphical data (*foundational literacies)* and justifying the validity of their conclusions (*epistemic knowledge).* Similarly, in controlling cross-examination, lawyers will manage how opposing expert evidence is challenged, for example, regarding the methods used by the opposing expert (*understanding of scientific practices*). Generally, all the above competencies need lawyers to have some "interest in science and technology"[98] (*dispositions and habits of mind).* Moreover, lawyers become judges, who then make other key, competency-based decisions about expert evidence, for example about admissibility, the bounds of direct and cross-examination, and the tools lawyers can use in both pursuits[99] – all enterprises that could be similarly mapped to the NAS science literacy concept.

Second, the decisions made by lawyers (and judges) in exercising their competencies matter. As Shooter and Cooper describe, "lawyers… have distinct and well-defined competencies in criminal proceedings involving forensic science, and appellate courts will generally defer to [lawyers'] original decision-making or — in some other way — emphasise [lawyers'] competence when reviewing decisions…"[100] Their work is foundational to jury decision-making, that is, if lawyers' abilities are optimised, it follows that jurors *should* be better positioned to perform their competencies, for instance in weighing the value of expert evidence.[101] An overhaul of this "deep reliance on [lawyers] to properly discharge their competencies" is unlikely.[102] They are the hands through which the criminal justice system aims to achieve justice — legitimate and accurate outcomes, public confidence, and the maintenance of social order.[103] Prioritising support for them makes sense.

Third, it has long been recognised that lawyers need support with understanding science. Generally, lawyers are not scientists and law schools have been considered "black hole[s]"[104] for science

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[95] Cooper & Shooter, *supra* note 7, at 23 (citing relevant scholarship in footnotes 208-213).
[96] David L. Faigman & Claire Lesikar, *Organized Common Sense: Some Lessons from Judge Jack Weinstein's Uncommonly Sensible Approach to Expert Evidence*, 64 DEPAUL L. REV. 421, 424 (2015) (emphasis added).
[97] Cooper & Shooter, *supra* note 7, at 5-6 (Summarising that, in criminal proceedings involving expert forensic science evidence, lawyers, judges, and jurors have distinct competencies that can be described in a broad sequence.)
[98] *Science Literacy, supra* note 8, at 30.
[99] Cooper & Shooter, *supra* note 7, at 21.
[100] *Id* at 11.
[101] *Id* at 21. ("The proper exercise of competencies by lawyers and judges is ground-laying for that of jurors, who play a passive role in trial proceedings. Essentially, if support for lawyers and trial judges is optimized, it follows that jurors will be better equipped to perform their competencies, as they would—through careful selection, presentation and challenges to scientific evidence by a lawyer—have access to a better toolkit on which to weigh the value of evidence.")
[102] *Id*.
[103] *Id*.
[104] Jessica D. Gabel, *Forensiphilia: Is Public Fascination with Forensic Science A Love Affair or Fatal Attraction?*, 36 NEW ENG. J. ON CRIM. & CIV. CONFINEMENT 233, 255–58 (2010).

and mathematics education.[105] This places lawyers "at a disadvantage when confronted with scientific evidence…."[106], and "ill-equipped to speak the language of science."[107] Concerns in this context can also be mapped to the NAS' science literacy concept. For example, it has been said lawyers lack subject knowledge (*content knowledge)*, backgrounds in scientific methodologies,[108] the ability to judge whether "proffered research is good science, bad science, or science at all,"[109] and criticality when accepting scientific assertions[110] (*understanding scientific practices* and *epistemic knowledge)*. Training for lawyers engaging with forensic science has been described as "clear[ly] important"[111] and a "considerable patchwork of support"[112] has amassed, yet there remains concern about the lack of mandatory, continuing, and assessed training on offer to lawyers.[113] There is "more to do in terms of developing a joined-up provision that meets, to the fullest extent possible, all relevant complexities and needs."[114] As recommended in *Strengthening* "better connections must be established and promoted between experts in the forensic science disciplines and law schools, legal scholars, and practitioners."[115]

The relevance of science literacy to legal practice and the need to support lawyers to develop their science literacy toolkit is clear. How we do that, though, is a more challenging enterprise, given the dearth of methodological work on science literacy and the law. What is apparent, however, is that any design must take account of the fact lawyers operate in a system with deeply embedded practices and practicalities that likely impact how they relate to the concept of science literacy.

Moreover, even a lawyer who is highly functioning against all dimensions of the science literacy concept, could still make decisions at odds with science. Two examples. First, the adversarial system – specifically its practices of "[v]igorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof"[116] – are considered the appropriate means to attack perceived flaws in admissible scientific or technical evidence.[117] By design, this model requires *adversaries* (i.e., defense and prosecution) to compete for the facts and application of the law to be determined. It encourages the presentation of compelling narratives, an approach not entirely well-suited to finding "scientific truth."[118] It can encourage the presentation of "highly practiced alternative stories that only roughly approximate what might be termed reality,"[119] and the selection of marginal experts because they are "willing to be . . . more certain of their conclusions."[120] Second, resourcing. Lawyers will need to navigate budget, administration, and workload, especially when operating in the criminal justice system where public funds resource most activity.[121] Forensic experts can be expensive

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[105] *Id.* For a review of forensic science provision in law schools see Brandon L. Garrett et. al., *Forensic Science in Legal Education*, 51 J.L. & EDUC. 1 (2022).
[106] Frederic I. Lederer, *Scientific Evidence--An Introduction*, 25 WM. & MARY L. REV. 517, 519-20 (1984) (citing Howard T. Markey, *Jurisprudence or "Juriscience"?*, 25 WM. & MARY L. REV. 525, 529-32 (1984)).
[107] Gabel, *supra* note 104, at 258.
[108] *Id.*
[109] Faigman, *supra* note 2, at 54.
[110] Lederer, *supra* note 106, at 519–20.
[111] National Commission on Forensic Science, Reflecting Back— Looking Toward the Future (2017) at 9 ("The Training on Science and the Law subcommittee was one of the first subcommittees created by the Commission. It was charged with the task of looking at training lawyers and judges on forensic science. What became clear over time was that this training was important…"). Available at, https://www.justice.gov/media/899496/dl?inline=. .
[112] Cooper & Shooter, *supra* note 7, at 23.
[113] *Strengthening*, supra note 6, at 234. ("However, these courses are not mandatory, there is no fixed routine of continuing education in legal practice with regard to science, and there are no good ways to measure the proficiency of judges who attend these programs.").
[114] Cooper & Shooter, *supra* note 7, at 23.
[115] *Strengthening*, *supra* note 6, at 238.
[116] Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579, 596 (1993) ("Vigorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence.").
[117] *Id.*
[118] *Strengthening*, *supra* note 6, at 12 ("The adversarial process relating to the admission and exclusion of scientific evidence is not suited to the task of finding "scientific truth.")
[119] Faigman, *supra* note 2, at 65.
[120] *Id* at 54.
[121] John Gross, *Reframing the Indigent Defense Crisis*, HARV. L. REV. BLOG, (Mar. 18, 2023), https://harvardlawreview.org/blog/2023/03/reframing-the-indigent-defense-crisis/, ("If we set aside traffic cases and we combine criminal cases with juvenile cases, which are considered quasi-criminal in nature and where the accused also has the right to counsel, then cases where the accused has the right to counsel make up almost half of the annual filings in state courts. And in those proceedings, according to a Department of Justice Report, over 80% of defendants are unable to afford counsel.").

to hire and involve time-consuming recruitment.[122] Moreover, most lawyers ration their time across clients, and "as a practical matter, reducing the number of trial errors [for instance, regarding scientific issues] would generally require attorneys to spend more time and resources representing each client."[123] These two examples demonstrate the tension for lawyers – their environment will likely have bearing on how they relate to the concept of science literacy. This needs to be accounted for in any research design, and Part III proposes a methodological framework that does just that.

PART III: A NEW METHODOLOGICAL APPROACH

This section proposes a new methodology for investigating how lawyers relate to the concept of science literacy, which takes account of their environment. It is inspired by the NAS' recommendation that conceptions of science literacy be expanded to the justice system,[124] and represents a drawing together of current understandings of, and best practices for researching, science literacy. It is presented in stages that gradually refine the inquiry's focus (as per *Figure 1*).

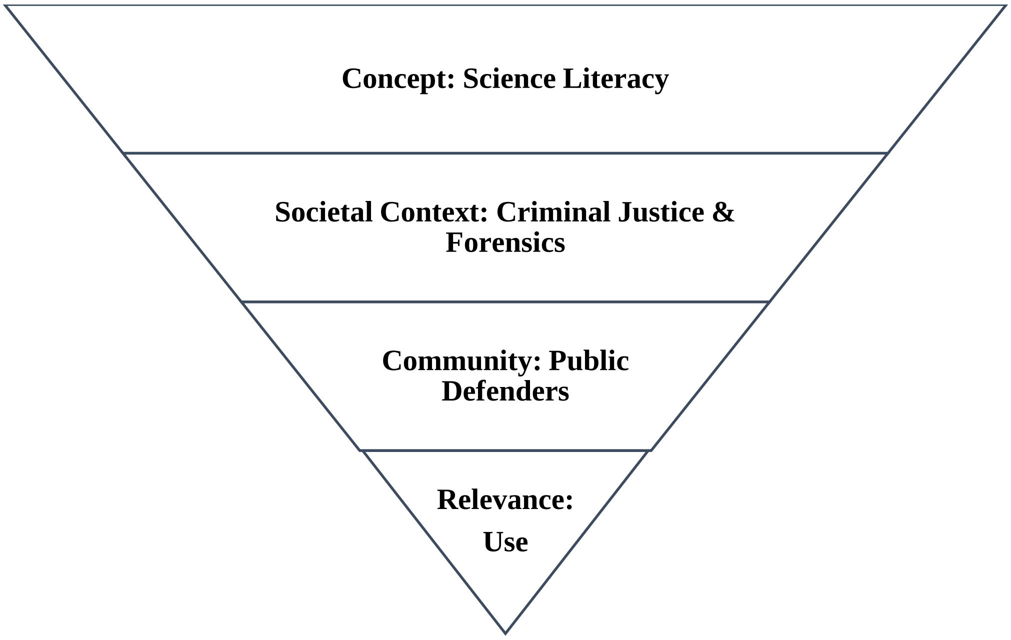

Figure 1: The Methodological Framework

1. *Concept: Science Literacy*

The starting point for the methodology is the NAS' science literacy concept, as described in Part II. This concept was presented in *Science Literacy: Concepts, Contexts, and Consequences (2016),* a report produced by the NAS in response to a request from the United States' National Institutes of Health to "study the role of science literacy in public support of science."[125] An aspect of this work was to "synthesize the available research literature on science literacy."[126] The result of this exercise, which included focus on the "the most prominent and influential definitions of science literacy,"[127] was the identification of "elements that are common to many, if not all, definitions."[128] The NAS presented

[122] See Brandon L. Garrett, Judging Innocence, 108 COLUM. L. REV. 55, 126 (2008) ("Our system of criminal review certainly does not privilege factual claims. Locating an alibi witness, obtaining experts to challenge forensic evidence or undermine eyewitness identifications, or presenting evidence of defendants' lack of capacity requires substantial resources and time.").
[123] Andrew Chongseh Kim, *Beyond Finality: How Making Criminal Judgments Less Final Can Further the "Interests of Finality"*, 2013 UTAH L. REV. 561, 564 (2013).
[124] *Science Literacy, supra* note 8, at 110-11.
[125] *Id* at 1.
[126] *Id*.
[127] *Id* at 30.
[128] *Id*.

these as seven dimensions (Table A) that represent a "sort of theoretical common ground"[129] of what many scholars would "*expect* [to] be useful or valuable."[130]

1	2	3	4	5	6	7
Foundational Literacies	Content Knowledge	Understanding the practices of science	Identifying and Judging Appropriate Scientific Expertise	Epistemic Knowledge	Cultural Understanding of Science	Habits of Mind and Disposition

Table A: The Seven Dimensions of the NAS' Science Literacy Concept.

As the product of a systematic, wide-ranging literature review by the US' "premier scientific think tank,"[131] the concept provides a strong overall frame and foundation for the inquiry. Collectively, these dimensions present a concept of science literacy and provide a structured and focused way to explore how lawyers relate to contemporary understanding of science literacy i.e., *how do lawyers relate to the dimensions of the concept?* This grounds the methodological framework and responds to calls for researchers to actively explore the demands of the legal system against this specific concept.[132]

2. Societal Context: Criminal Justice and Forensics

There is need to locate the investigation in a societal context. The author's synthesis of the literature suggests a helpful way to do this is to select a *societal system* that requires its agents to have *deeper levels of science literacy* to address *issues* that bring those needs into focus. This sub-section takes those emphasized elements in turn.

Societal systems are a "patterned series of interrelationships existing between individuals, groups, and institutions"[133] that form a coherent whole. They can govern and shape behaviours within, and differ across, society because of class-based, regional, and/or cultural differences. There is limited understanding of the value science literacy in-action plays in society and, specifically, within societal systems,[134] which can themselves comprise features that "enable or constrain the development of science literacy."[135] Considering points made in Part II, it is unsurprising that the NAS explicitly recognised the justice system as one of these systems: "[T]he justice system, ….also shape[s] how people interact with each other, with institutions, and with science information."[136] Appreciating the sheer enormity of the justice system, a sub-system needs to be selected. The criminal justice system is proposed for reasons related to the other elements, namely agents and issues.

Within societal systems "people need different levels of science literacy at different times to accomplish their personal and civic goals"[137] As described in Part II, given the scope and nature of their roles in meting out justice, lawyers operating in the criminal justice system fit this description. This, too, has been specifically recognised: "Participation in particular social systems requires different deeper levels of science literacy. For example, citizens participating in the legal system (… lawyers, ….) may require different understanding of scientific concepts for justice to be served."[138] The criminal justice system can involve various issues that bring lawyers' science literacy into focus, and as described

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[129] *Id* at 32.
[130] *Id*. [emphasis in the original].
[131] Cooper & Shooter, *supra* note 7, at 4.
[132] *Science Literacy, supra* note 8, at 111. ("[W]hat level of understanding of scientific principles, methodologies, and habits of mind are needed for the proper and equitable operation of the justice system.")
[133] "Social system." Merriam-Webster.com Dictionary, Merriam-Webster, https://www.merriam-webster.com/dictionary/social%20system. (last visited Dec.22, 2023).
[134] *Science Literacy, supra* note 8, at 111.
[135] *Id*.
[136] *Id* at 67.
[137] Id at 110.
[138] *Id* 110-11.

in Parts I and II, the application of forensic science techniques to solve crime is one of them. Notably, this was explicitly raised in *Science Literacy: Concepts, Contexts, and Consequences*:

> "In the justice system, for example, rising use as well as criticism of forensic science evidence … [is] increasing awareness of the need for science literacy among participants in court proceedings. Although this situation is hardly new, it is becoming increasingly difficult to ignore … Rising awareness of the need for science literacy among citizens and professional jurists engaged in litigation serves as a call to the justice system to examine structures that promote and support science literacy in legal contexts and serve to provide relevant scientific information and training to judges, attorneys, and juries as necessary."[139]

Collectively, these elements enable us to locate an investigation of how lawyers relate to the science literacy concept in a societal context, namely the criminal justice system's use of forensic science.

3. *Community: The Public Defender*

To date, science literacy research has largely focused on the individual.[140] There is a call to complement this with research that examines, "how science literacy emerges in communities of people working together,"[141] specifically the development and use of science literacy in communities and its value in achieving community goals.[142] This has been coined the "structural perspective"[143] – an approach that takes account of how social structures "likely contribute to science literacy"[144] and "inform what people know, think, and feel."[145] Focusing on communities acknowledges that, in a community, science literacy does not require individuals to attain particular thresholds, but rather "it is a matter of [a] community having sufficient shared capability necessary to address a science-related issue."[146] Therefore, the methodology must incorporate an appropriate community of lawyers.

Lawyers operating within the criminal justice system largely fall within two categories: prosecutors and defense lawyers. The most common defense lawyer is the state-based public defender, whose offices, in the US, "handle the largest proportion of indigent defense cases of the three major indigent defense delivery systems."[147] These lawyers provide a fitting focus community. First, the scale of the US public defender system provides a large data pool. The last Census of Public Defender Offices reported a remit of over 1000 offices, with 957 in 49 states (and DC) providing defense services to indigent clients.[148] These offices are found in the US' most populous counties,[149] and collectively employ more than 15,000 litigating attorneys.[150] Annually, system expenditure is around $2.3 billion,

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[139] *Id* at 69.
[140] *Id* at 4 ("We refer to the first one as the aggregate perspective— empirical work that aggregates data about individuals, usually collected through large public opinion surveys or tests with samples representative of a population, and examines patterns in the whole or by groups. The vast majority of scholarly inquiry at the society level in the field of science literacy, as well as the public discourse, has focused on the aggregate perspective.").
[141] *Id* at 43.
[142] *Id* at 84.
[143] *Id* at 4.
[144] *Id* at 48.
[145] *Id*.
[146] *Id* at 73.
[147] BUREAU JUST. STAT., CENSUS OF PUBLIC DEFENDER OFFICES (CPDO) (2007), https://bjs.ojp.gov/data-collection/census-public-defender-offices-cpdo#methodology-0_("These public defender offices handle the largest proportion of indigent defense cases of the three major indigent defense delivery systems: public defender offices, assigned counsel systems, and contract attorney systems.").
[148] See, Lynn Langton & Donald J. Farole Jr., *Bureau of Justice Statistics Selected Findings: Public Defender Offices, 2007 – Statistical Tables*, U.S. DEP'T JUST., https://bjs.ojp.gov/content/pub/pdf/pdo07st.pdf ("In 2007 a total of 957 public defender offices in 49 states and the District of Columbia provided defense services for indigent clients."). Note, in 2022, the Department of Justice/Bureau of Statistics publicised a call for applications to carry out a new Census. See, BUREAU JUST. STAT., FY 2022 CENSUS OF PUBLIC DEFENDER OFFICES (2022), https://bjs.ojp.gov/funding/opportunities/o-bjs-2022-171331#:~:text=The%20census%20will%20obtain%20information,defender%20offices%20across%20the%20nation.
[149] PAUL B. WICE, PUBLIC DEFENDERS AND THE AMERICAN JUSTICE SYSTEM 10 (2005).
[150] See, Langton & Farole Jr., *supra* note 148, at 1.

millions of cases are received (including misdemeanours and non-capital and capital felonies), [151] and median receivals per litigating attorney, at state and county levels, are reported in the hundreds.[152]

Second, public defenders form a "group [] of people who are functionally interconnected in a way that enables exchange of information and are typically defined by shared goals and interests…."[153] – a recognised definition of community in the context of science literacy. There is a level of organizational structure to public defender offices, including in the way they are resourced, approach qualifying people for indigent services, provide performance standards and guidelines for lawyers (including continuing professional development); have distinct roles and hierarchies (i.e., Assistant Public Defender, Supervising Attorney, Chief Public Defender etc), and are supported by a range of other professional roles (e.g., investigators and paralegals).[154] Reflecting the system's constitutional roots,[155] public defender offices also have a clear shared mission, namely to provide effective legal representation to the indigent. Third, the above two points merge to mean that public defenders possibly have an acute (and shared) experience of the *practices* and *practicalities* of law's approach to the world. This includes handling high caseloads and crowded dockets, and having limited resources, experience, and preparatory education.[156] Indeed, public defenders are operating within what has been described as "a genuine national crisis regarding the right to counsel in criminal cases for poor people."[157] In short, they likely experience the sorts of structural disparities, like distribution of resource and access to education, that impact science literacy.

Finally, we can reasonably assume that knowledge of science is "an important tool"[158] in pursuit of the public defender's mission to deliver effective legal representation. In other words, being science literate, whether it is stated explicitly or not, is a logical goal for the public defender community. With that in mind, existing research would suggest they are an appropriate object of study because they likely comprise, collectively, the sorts of qualities associated with a community being "socially positioned"[159] to mobilise towards a science literacy-related goal, for example in terms of class, education, political clout, fundraising capabilities, and "unique access to the particular realm they hope[] to affect."[160]

In taking this approach, the methodological framework serves the NAS' call for "the justice system to examine structures that promote and support science literacy in legal contexts."[161] It brings a structural perspective to the inquiry. Now we can ask: how do public defenders, operating within the structures of both the state public defender and criminal justice systems, and engaging with forensic science, relate to the concept of science literacy?

4. Relevance

The final aspect of the framework clarifies what is meant by the term "relate" with respect to the science literacy concept. Here, Feinstein's *Competent Outsider* - someone who is "anchored outside of science, reaching in for bits and pieces that enrich their understanding of their own lives"[162] – provides direction. Feinstein proposes that "science literate people are competent outsiders with respect to science,"[163] they are "people who have learned to recognize the moments when science has some bearing on their needs and interests and to interact with sources of scientific expertise in ways that help

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151 *Id*.
152 *Id* at page 2.
153 *Science Literacy, supra* note 8, at 74.
154 See, generally, Langton & Farole Jr., *supra* note 148.
155 Gideon v. Wainwright, 372 U.S. 335 (1963).
156 See, generally, Mary Sue Backus & Paul Marcus, *The Right to Counsel in Criminal Cases: Still A National Crisis?*, 86 GEO. WASH. L. REV. 1564 (2018).
157 *Id* at 1566.
158 *Science Literacy, supra* note 8, at 77 ("Knowledge of science is often perceived by community groups as an important tool in pursuit of their goals.")
159 *Id* at 74-75 (describing Steven Epstein's work on AIDS activists).
160 *Id*.
161 *Id* at 69.
162 Feinstein, *supra* note 24, at 180.
163 *Id* at 183.

them achieve their own goals."[164] This description is generally fitting for lawyers: they engage with science as they – or a case/client – need it. As Osborne *et al* describe, the starting point of realizing the competent outsider is figuring out what is required to be a competent outsider.[165] Or, as Feinstein says, it is "fundamentally about identifying relevance: learning to see how science is or could be significant to the things you care about most."[166]

This task requires centering "daily life"[167] and recognising that "many engage with science in response to situation-specific needs and tend to be interested in science only insofar as it helps them solve their problems."[168] Taking an approach that identifies and analyses the relevance of science in criminal justice has been explicitly recommended by the NAS:

> "Where the legal system is concerned, it is particularly important to know what fields of science are most frequently referenced in the legal arena and what level of understanding of scientific principles, methodologies, and habits of mind are needed for the proper and equitable operation of the justice system."[169]

Harnessing this direction, we can decipher meaning in the word "relate" in the inquiry we are framing. It refers to how the seven dimensions of the science literacy concept are relevant to public defenders' routine legal practice. In criminal cases involving forensic science what dimensions do they use: why, when, and how?

CONCLUSIONS

This paper theorises a new way to work towards a better understanding of the intricate relationship between science literacy and the law, particularly within the realm of criminal justice and forensic science. It argues that existing research on science literacy serves as both a roadmap and catalyst for (re)imagining methodologies to investigate how lawyers, as critical agents of the justice system, relate to the concept of science literacy. This is important to finding ways to reconcile disciplinary differences between the institutions of law and science, particularly through developing effective science training and education for lawyers.

Part I laid groundwork for the new methodological framework by illustrating the nuanced intersections of law and science, as presented by the criminal justice system's use of forensic science. It suggested that the courts' approach to uncertainties at this intersection necessitate the development of research strategies that can bridge legal and science perspectives by taking proper account of law's approach to the world. In the context of criminal justice and forensics, Part II proposed that exploring how lawyers relate to science literacy is an appropriate strategy, through defining science literacy, presenting its pertinence to legal practice both in terms of lawyers' competencies and concerns about their scientific expertise, the points at which science becomes relevant, and appreciating how the nature of legal practice could impact how lawyers perceive and interact with science literacy.

It is within this context that the methodological framework, developed in Part III, assumes significance. By leveraging research from across the science literacy field and, specifically, the National Academy of Sciences' conceptualization of science literacy and call for focus on justice systems, the framework directs research attention towards – and joins up – societal systems, community structures,

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[164] *Id* at 180.
[165] Osborne, J., & Pimentel, D., *Science Education in an Age of Misinformation*, SCI. EDUC., 107, 553–571 (2023) ("In what follows, we lay out our arguments for why it is time to rethink the conception of scientific literacy by considering what it requires to be a competent outsider to science."). They also note that Feinstein stopped short of stating what was required to operationalize the concept, although others have made efforts to systematically articulate such things in the context of science media literacy.
[166] Feinstein, *supra* note 24, at 180.
[167] *Id* at 183. ("I have since argued that we can salvage science literacy—make it into a meaningful educational goal instead of a mere slogan—by redefining it according to research on the actual uses of science in daily life.")
[168] Noah W. Feinstein , Sue Allen, Edgar Jenkins, *Outside the Pipeline: Reimagining Science Education for Nonscientists*, 340(6130) SCI. 314..
[169] *Science Literacy, supra* note 8, at 111.

daily use of science literacy, framing an inquiry into how public defenders, operating in the state public defender and criminal justice systems, relate to science literacy in terms of relevance and use when dealing with cases involving forensic science. As such, a constructive framework for investigating, understanding, and potentially reconciling disparities between legal and scientific perspectives, in context, is proposed. Focus should now turn to ways to refine and operationalise that framework.