A CASE FOR CONCEPTUALISING SCIENCE LITERACY FOR LAWYERS

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Abstract

Forensic science is routinely used in the service of the United States criminal justice system. In such cases, lawyers, judges and jurors each have distinct competencies. Trial judges must determine the admissibility of expert evidence and deliver jury instructions; lawyers must select, present, and challenge the evidence; and jurors must determine the weight of the evidence. As they discharge these competencies, each agent must often engage with the often unfamiliar methods introduced and discussed by a forensic science expert. These activities represent an intersection between law and science – two culturally divergent disciplines — where it is recognised science literacy — "the disposition and knowledge needed to engage with science" — for legal professionals and jurors is important to serving justice. There are limitations, however, in current provision for supporting legal professionals to develop their science literacy, which is foundational to optimising the carrying out of juror competencies. Despite this, the criminal justice system is organised in such a way as to routinely defer to the decision-making competencies of lawyers, judges, and jurors. Through a content analysis of case law referencing the National Academy of Sciences' (NAS) forensic science report portfolio in criminal proceedings — which is positioned as a case study — this paper demonstrates how this systemic practice — driven by the legal system's fidelity to factors associated with the legal process vision — should motivate stakeholders to prioritise delivery of a meaningful science literacy provision for lawyers. Part I broadly outlines the roles of lawyers, judges and jurors in criminal legal proceedings involving forensic science evidence, explaining this interaction as an intersection of law and science. Part II describes our research design, including the rationale for selecting case law referencing the NAS' forensic science report portfolio as a case study. Part III presents our findings in three thematic areas: (1) deference to lawyers' strategic decisions, particularly in the context of cross-examination; (2) deference to the gatekeeping function of trial judges and the role of precedent; and (3) deference to the jury's fact-finding role. It concludes that these findings, coupled with the reality that an institutional overhaul is unlikely, should focus minds on supporting — as a priority— lawyers to develop their science literacy, and that conceptualising 'science literacy' for lawyers is a necessary step in moving towards that goal.

INTRODUCTION

Forensic science evidence is used "routinely in the service of the criminal justice system"[2] and has "long been at the forefront in answering complicated questions brought before the bar of justice."[3] In such cases, judges, lawyers, and jurors each have distinct competencies. Trial judges

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[2] THE COMM. ON IDENTIFYING THE NEEDS OF THE FORENSIC SCI. CMTY., NAT'L RESEARCH COUNCIL OF THE NAT'L ACADS., STRENGTHENING THE FORENSIC SCIENCES IN THE UNITED STATES: A PATH FORWARD 9 (National Academies Press2009) [hereinafter *Strengthening*].

[3] Matthew F. Redle & Hon. Christopher J. Plourd, *A Path Forward the Value of Forensic Science Standards Development and Use to the American Legal System*, CRIM. JUST., FALL 2020 61.

must determine the admissibility of expert evidence and deliver jury instructions; lawyers must select, present, and challenge the evidence; and jurors must determine the weight of the evidence.[4]

However, there is limited education and training for these key agents with respect to supporting them to evaluate forensic science evidence,[5] a situation recognised by the National Academy of Sciences (NAS) — the US' premier scientific think tank. Since the early 1990s, following the introduction of DNA technology within the criminal justice system, the NAS has reported on various forensic disciplines — including DNA, polygraph, ballistics, fingerprint and bite-mark evidence — parallel to (and sometimes motivated by) growing interest in their reliability.[6] Following a critical appraisal of the entire field,[7] in 2009 the NAS recommended that Congress establish an independent oversight body to monitor implementation of its recommendations,[8] which included support measures for lawyers, judges, and jurors.[9] A comprehensive support package, however, has not fully emerged. Yet, the need for one remains. This is because the criminal justice system is organised in such a way as to routinely defer to the decision-making competencies of these agents, and that configuration is unlikely to change.

Through a content analysis of case law this paper posits this organisational practice is driven by — as we have suggested previously — the criminal justice system's fidelity to factors associated with the legal process vision.[10] Part I broadly outlines key competencies of lawyers, judges and jurors in criminal legal proceedings involving forensic science evidence, explaining them as an intersection of two culturally divergent disciplines: law and science. Part II describes our research design, which used case law referencing the NAS' forensic science report portfolio as a case study. Part III presents our findings in three thematic areas: (1) deference to lawyers' strategic decisions, particularly in the context of cross-examination; (2) deference to the gatekeeping function of trial judges and the role of precedent; and (3) deference to the jury's fact-finding role. It concludes that these findings, coupled with the reality that an institutional overhaul is unlikely, should focus minds on the need to develop an appropriate education and training support package for lawyers, as a priority group. We suggest conceptualising 'science (or scientific) literacy' — "the disposition and knowledge needed to engage with science"[11] — for lawyers is a necessary step in moving towards this goal, and offer the criminal justice system's consumption of forensic science as a possible exploratory case study.

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[4] Obviously, many more agents are involved in criminal proceedings, and experts are particularly relevant the competencies summarised in this opening paragraph. The focus of this paper, however, is on specific competencies of lawyers, judges and jurors i.e., non-experts in a scientific sense.

[5] See, *Strengthening*, *supra* note 2 at 26-28 (summarising the Committee's findings regarding "Insufficient Education and Training").

[6] See, Amelia Shooter & Sarah L. Cooper, *A Template for Enhancing the Impact of the National Academy of Sciences' Reporting on Forensic Science, 8* BR. J. AM. STUDIES (Special Issue) 443 (2019).

[7] *Strengthening*, *supra* note 2 at *xix* ("Recognizing that significant improvements are needed in forensic science, Congress directed the National Academy of Sciences to undertake the study that led to this report…In adopting this report, the aim of our committee is to chart an agenda for progress in the forensic science community and its scientific disciplines.")

[8] *Id.* at 80 - 83.

[9] *Id.* at 26-28.

[10] *See, e.g.,*, Shooter & Cooper, *supra* note 6 at 462; Sarah Lucy 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. LEGAL STUD. 649 (2015); and Sarah Lucy Cooper, *Judicial Responses to Challenges to Firearms-Identification Evidence: A Need for New Judicial Perspectives on Finality*, 31 W. MICH. U.T.M. COOLEY L. REV. 457 (2014).

[11] COMMITTEE ON SCIENCE LITERACY AND PUBLIC PERCEPTION OF SCIENCE, , SCIENCE LITERACY: CONCEPTS, CONTEXTS, AND CONSEQUENCES 27 (National Academies Press 2016) [*hereinafter Science Literacy*].

PART I: COMPETENCIES AND CULTURAL DIFFERENCES

In criminal proceedings involving expert forensic science evidence, lawyers, judges and jurors have distinct competencies that can be described in a broad sequence.

Lawyers, in line with their monopoly on determining case strategy, must first decide whether to include expert evidence within their case. A lawyer will call upon an expert if s/he [the expert] has "scientific, technical, or other specialized knowledge"[12] capable of assisting the fact-finder to understand the evidence in a case and/or to resolve a contentious fact. For example, a lawyer might need a firearms examiner to compare ammunition found at a crime scene to ammunition test-fired from a client's firearm. Applying the "reliable principles and methods"[13] of their discipline (for example, the discipline of firearms identification) to the case facts, experts are expected to use their experience and training to testify to opinions (for example, whether the defendant's firearm discharged suspect ammunition) based on "sufficient facts and data."[14]

Trial judges are tasked with safeguarding this expectation. In overseeing evidentiary and *in limine* hearings, they must make admissibility decisions that ensure only relevant and reliable expert evidence is admitted in proceedings. In so deciding, they generally consider whether a method: can or has been tested; has a known or potential error rate; has been subject to peer review; has standards controlling its operation; and is generally accepted within the relevant community.[15] If expert evidence is deemed admissible, lawyers will, through their oversight of direct-examination, shape how it is presented on behalf of their party at trial. For example, they will design questions to elicit an expert's qualifications, experience, methods, and findings (for example, how a firearms examiner made their comparison between suspect and test-fired ammunition). In controlling cross-examination, lawyers also shape how opposing expert evidence is challenged; designing questions to, for example, highlight limitations in an opposing expert's methods and findings (for example, limitations associated with expert subjectivity).

In their role as fact-finders, jurors are then charged with weighing the probative value of expert evidence alongside all other evidence presented. Trial judges may provide jury instructions to inform this task. Model instructions typically remind jurors about the witness's expertise; that they can afford as much weight (including no weight) to the expert's testimony; and what factors they

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[12] Fed. R. Evid. 702. The federal framework is provided by way of a general example.

[13] *Id.*

[14] *Id.*

[15] Daubert v. Merrell Dow Pharmaceuticals Inc., 509 U.S. 579, 591-94 (1993). Note § 45:5. Fed. R. Evid. 702 and corresponding state law, 6 Jones on Evidence § 45:5 (7th ed.) ("Although Daubert is only binding on federal courts, many states have expressly adopted its standard or apply the Daubert factors in interpreting their own rules of evidence. Some states continue to follow Frye while others apply their own, separate framework or a hybrid approach.")

may take into consideration, such as qualifications, and the reliability of the information underpinning the expert's opinion.[16] Jurors then determine a verdict.

Finally, if a defendant is convicted, a lawyer may later bring appeal proceedings. Most appeals allege errors in procedural regularity, which could involve claims that a lawyer, judge, and/or jury discharged competencies improperly.

Law & Science

The above sequence represents an intersection between two culturally divergent disciplines: law and science, a relationship that has been described as "an uneasy alliance."[17] The two disciplines can be "strange partners"[18] given their different approaches to the world.[19] These differences present "both systemic and pragmatic dilemmas for the law and the actors within it…"[20] This includes knowledge gaps of various shapes. Legal education has been described as a "black hole" for STEM education,[21] leading to judges and lawyers "generally lack[ing] the scientific expertise necessary to comprehend and evaluate forensic evidence in an informed manner."[22] Similar concerns exist about jurors.[23] At the same time, there still remains much to determine within individual forensic disciplines, especially with regards to scientific validity:

> "The simple reality is that the interpretation of forensic evidence is not always based on scientific studies to determine its validity. This is a serious problem. Although research has

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16 See, for example, Model Crim. Jury Instr. 8th Cir. 4.10 (2021), Model Crim. Jury Instr. 8th Cir. 4.10 (2021) ("You have heard testimony from persons described as experts. Persons who, by knowledge, skill, training, education or experience, have become expert in some field may state their opinions on matters in that field and may also state the reasons for their opinion. Expert testimony should be considered just like any other testimony. You may accept or reject it, and give it as much weight as you think it deserves, considering the witness' education and experience, the soundness of the reasons given for the opinion, the acceptability of the methods used, and all the other evidence in the case.") Another example is Mod. Crim. Jury Instr. 3rd Cir. 2.09 (2021), Mod. Crim. Jury Instr. 3rd Cir. 2.09 (2021) ("You will hear testimony from (state the name of the person(s) who will offer an opinion). Because of (his)(her)(their) knowledge, skill, experience, training, or education in the field of (state the witness(es)'s field), (Mr.)(Ms.)(Dr.)(name) will be permitted to offer (an) opinion(s) in that field and the reasons for (that)(those) opinion(s).The opinion(s)(this)(these) witness(es) state(s) should receive whatever weight you think appropriate, given all the other evidence in the case. In weighing this opinion testimony you may consider the witness' qualifications, the reasons for the witness' opinions, and the reliability of the information supporting the witness' opinions, as well as the other factors I will discuss in my final instructions for weighing the testimony of witnesses. You may disregard the opinion(s) entirely if you decide that (Mr.)(Ms.)(Dr.)(name)'s opinion(s)(is)(are) not based on sufficient knowledge, skill, experience, training, or education. You may also disregard the opinion(s) if you conclude that the reasons given in support of the opinion(s) are not sound, or if you conclude that the opinion(s)(is)(are) not supported by the facts shown by the evidence, or if you think that the opinion(s)(is)(are) outweighed by other evidence."

17 *Strengthening*, *supra* note 2, at 86.

18 Redle & Plourd, *supra* note 3, at 61.

19 *Id.* ("Science is an empirical method of learning anchored to the principals of observation and discovery as to how the natural world works. Scientific knowledge advances human understanding by developing experiments that provide the scientist with an objective answer to the question presented. Through a scientific method of study, a scientist systematically observes physical evidence and methodically records the data that support the scientific process. The law, on the other hand, starts out with at least two competing parties who use the courthouse as a battleground to resolve factual issues within the context of constitutional, statutory, and decisional law. In science, all answers are provisional, while the law seeks finality. ") DAVID L. FAIGMAN, LEGAL ALCHEMY: THE USE AND MISUSE OF SCIENCE IN THE LAW 56 (Freeman 1999) ("[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."); M.A. Berger and L.M. Solan. *The uneasy relationship between science and law: An essay and introduction*. 73 BROOK. L. REV. 847 (2008).

20 *Confronting the New Challenges of Scientific Evidence* I. Introduction, 108 HARV. L. REV. 1481, 1484 (1995).

21 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, 257-8 (2010).

22 *Strengthening*, *supra* note 2, at 86.

23 *Id.* at 236-7. Sarah Lucy Cooper, *Challenges to Fingerprint Identification Evidence: Why the Courts Need A New Approach to Finality*, 42 MITCHELL HAMLINE L. REV. 757-8 (2016). Note it is also recognised that forensic examiners require up-skilling. *See*, *Strengthening*, *supra* note 2 at 238 ("Forensic science examiners need additional training in the principles, practices, and contexts of scientific methodology, as well as in the distinctive features of their specialty.")

> been done in some disciplines, there is a notable dearth of peer-reviewed, published studies establishing the scientific bases and validity of many forensic methods."[24]

These gaps can be exacerbated by the adversarial system. Adversarial practices can improperly polarise forensic science evidence — "information that reaches the legal system does not represent the scientific field more generally…"[25] — and can blur reality, with "[jurors] hear[ing] highly practiced alternative stories that only roughly approximate what might be termed reality."[26] Experts at the "margins of their disciplines"[27] can be "chosen . . . because they are willing to be ... more certain of their conclusions."[28] In fact, it has been stated the "criminal justice system does far too little to grapple with the implications of scientific change for its truth-finding functions."[29]

The criminal justice system has been struggling with — in particular — these knowledge gaps relating to forensic science since the introduction of DNA evidence in the 1980s.[30] This is not surprising. When science progresses, challenges can often emerge in law. The law "will always lag behind the sciences to some degree because of the need for solid scientific consensus before the law incorporates its teachings.""[31] As Laurin describes, "Law cannot, of course, fully bend to science's pace and manner of truth production."[32] Yet, as Albright and Garrett suggest,

> "The "law incorporating the teachings" of science should not remain static. "The law" need not wait for "finished" science, either…. law should use standards sufficiently flexible to incorporate an evolving scientific understanding of the world in which we live."[33]

As agents of the law, lawyers, judges and jurors are key to properly incorporating the teachings of science into the criminal justice system. Developing a deeper understanding of their competencies in cases involving scientific evidence, including forensic science, is therefore instructive to finding out what support they need to properly discharge their competencies.

PART II: THE NATIONAL ACADEMY OF SCIENCES' FORENSIC SCIENCE PORTFOLIO AS A CASE STUDY

Broadly, our objective was to explore the how the competencies of lawyers, judges, and jurors are considered and promoted in criminal proceedings involving claims concerning forensic sci-

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[24] *Strengthening*, *supra* note 2, at 8. For a recent account, see Maneka Sinha, *Radically Reimagining Forensic Evidence*, 73 ALA. L. REV. 879 (2022).

[25] Faigman, *supra* note 19, at 65.

[26] *Id.*

[27] *Id* at 54.

[28] *Id.*

[29] Jennifer E. Laurin, *Criminal Law's Science Lag: How Criminal Justice Meets Changed Scientific Understanding*, 93 TEX. L. REV. 1751, 1753 (2015).

[30] *Strengthening*, *supra* note 2, at 40 ("In the 1980s, the opportunity to use the techniques of DNA technologies to identify individuals for forensic and other purposes became apparent.").

[31] Brodes v. State, 614 S.E.2d 766, 771 (Ga. 2005) (quoting State v. Long, 721 P.2d 483, 491 (Utah 1986)).

[32] Laurin, *supra* note 29, at 1753.

[33] Thomas D. Albright & Brandon L. Garrett, *The Law and Science of Eyewitness Evidence*, 102 B.U. L. REV. 511, 578 (2022)

ence. What is expected of them? What drives those expectations? One way to explore this objective is through analysing case law, and — based on Shooter's previous research[34] — we knew case law referencing the NAS' forensic science report portfolio would be helpful.

The National Academy of Sciences & Forensic Science Reporting

The NAS, established in 1863, is the US' leading science and technology think-tank. Designed to provide "independent, objective advice to the nation on matters related to science and technology,"[35] it carries a statutory mandate to report on any scientific subject when called upon by the federal government.[36] The NAS is committed to "furthering science in America"[37] and its members are "active contributors to the international scientific community."[38] Over time, the NAS has developed a diverse research portfolio, including reports on matters of national security and welfare,[39] warfare technology,[40] education,[41] healthcare (including COVID-19)[42], climate change,[43] and forensic science.

The NAS' forensic science portfolio includes six reports of particular relevance to the criminal justice system ["the portfolio"]. To answer questions about the introduction of DNA evidence into legal proceedings in the late 1980s, the NAS published two reports — *DNA Technology in Forensic Science* (1992)[44] and *The Evaluation of Forensic DNA Evidence* (1996)[45] — on the forensic use of DNA technology. Both reports were in part funded by the US Department of Justice.[46] The earlier report focused on resolving the DNA "admissibility wars"[47] and the latter answered

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[34] Amelia Shooter, 100 Years of the National Research Council: A Critical Examination of Judicial References to Forensic Science NAS Reports (November 2019) (unpublished Ph.D thesis, Birmingham City University) (on file with the author). This thesis explored case law to determine that judicial decision-making is inherently linked to one (or more) of four factors – following precedent, institutional settlement, finality and rationality. The first two justifications demonstrate that the role of judges, lawyers and juries is key in ensuring that good decision-making takes place, particularly when said agents are deliberating on scientific evidence.

[35] National Academy of Sciences, *Mission*, http://www.nasonline.org/about-nas/mission/ (last visited, August 26, 2022).

[36] An Act to Incorporate the National Academy of Sciences, 36 U.S.C §251 et seq. (1863).

[37] National Academy of Sciences, *supra* note 35.

[38] *Id*.

[39] Albert L. Barrows, *The Relationship of the National Research Council to Industrial Research, in* RESEARCH: A NATIONAL RESOURCE: II: INDUSTRIAL RESEARCH 365 (United States Government Printing Office1940).

[40] *Id* at 396-7.

[41] National Research Council, A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press (2012).

[42] National Academy of Sciences, *Coronavirus Resources Collection*, http://www.nap.edu/collection/94/coronavirus-resources (last visited August 22, 2022).

[43] National Academies of Sciences, Engineering, and Medicine, Future Water Priorities for the Nation: Directions for the U.S. Geological Survey Water Mission Area. Washington, DC: The National Academies Press (2018).

[44] COMMITTEE ON DNA TECHNOLOGY IN FORENSIC SCIENCE., DNA TECHNOLOGY IN FORENSIC SCIENCE (National Academies Press1992)

[45] COMMITTEE ON D NA FORENSIC SCIENCE: AN UPDATE., THE EVALUATION OF FORENSIC DNA EVIDENCE (National Aademies Press1996).

[46] *DNA Technology in Forensic Science*, *supra* note 44.

[47] *Id.,* at 32.

questions about Polymerase Chain Reaction (PCR) methods.[48] In sum, the NAS encouraged the criminal justice system to harness properly prepared DNA technology on that the basis that scientific evidence demonstrated the technology's high reliability.[49] In four reports that followed, the NAS reported on several non-DNA forensic science techniques.[50] Three of these reports focused on specific disciplines. In *The Polygraph and Lie Detection* (2003)[51] the NAS concluded polygraph testing exhibited accuracy "considerably better than chance"[52] under controlled conditions, but fell "far short"[53] of what would be desirable. In 2002, the FBI commissioned the NAS to produce "an impartial scientific assessment of the soundness of the scientific principles underlying CBLA [Comparative Bullet-Lead Analysis] to determine the optimum manner for conducting the examination and to establish scientifically valid conclusions."[54] In the report that followed — *Forensic Analysis: Weighing Bullet Lead Evidence* (2004)[55] — the NAS found some merit in the FBI's method for comparing the chemical composition of bullet fragments,[56] but reported a range of concerns including about FBI reporting procedures,[57] variability of bullets and manufacturing processes,[58] and interpretation evidence.[59] The NAS recommended further research in the area[60] and that the FBI strengthen its protocols.[61] In 2005, the FBI stopped using CBLA.[62] In *Ballistic Imaging* (2008),[63] the NAS recommended against the establishment of a national ballistics database,[64] commenting

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48 *The Evaluation of Forensic DNA Evidence, supra* note 45, at 177.

49 *Id.,* at 204.

50 The report, The Polygraph and Lie Detection (2003) was commissioned by the United States Department of Energy (COMMITTEE TO REVIEW THE SCIENTIFIC EVIDENCE ON THE POLYGRAPH, THE POLYGRAPH AND LIE DETECTION (National Academies Press 2003));, Forensic Analysis: Weighing Bullet Lead Evidence (2004) was commissioned by the FBI (COMMITTEE ON SCIENTIFIC ASSESSMENT OF BULLET LEAD ELEMENTAL COMPOSITION COMPARISON, FORENSIC ANALYSIS: WEIGHING BULLET LEAD EVIDENCE (National Academies Press 2004));, Ballistic Imaging (2008) was commissioned by the National Institute of Justice (COMMITTEE TO ASSESS THE FEASIBILITY, ACCURACY AND TECHNICAL CAPABILITY OF A NATIONAL BALLISTICS DATABASE, BALLISTIC IMAGING (National Academies Press 2008)), and Strengthening Forensic Science in the United States: A Path Forward (2009) was commissioned by Congress (*Strengthening,* supra note 2).

51, THE POLYGRAPH AND LIE DETECTION, *supra* note 50.

52 *Id* at 224.

53 *Id*.

54 FORENSIC ANALYSIS: WEIGHING BULLET LEAD EVIDENCE, *supra* note 50

55 *Id*. Note, throughout the report, CBLA evidence is referred to as CABL, or comparative analysis of bullet lead.

56 *Id* at 23.

57 *Id* at 16.

58 *Id* at 68.

59 *Id* at 107.

60 *Id* at 106.

61 *Id* at 109-10.

62 FBI National Press Office, FBI Laboratory Announces Discontinuation of Bullet Lead Examinations (Sept. 1, 2005) https://archives.fbi.gov/archives/news/pressrel/press-releases/fbi-laboratory-announces-discontinuation-of-bullet-lead-examinations.

63 BALLISTIC IMAGING, *supra* note 50.

64 *Id.,* at 5.

that the uniqueness of firearms-related tool-marks had not been fully demonstrated.[65] The fourth, *Strengthening Forensic Science in the United States: A Path Forward* (2009), provided a broader evaluation of the forensic science field, following a commission from the US Congress.[66] It provided a critique of several commonly used forensic science disciplines, including the analysis of fingerprint,[67] ballistics,[68] bite-marks,[69] and hairs.[70] The report's key findings included that, on the basis of existing evidence, only nuclear DNA technology was capable of individualisation consistently and with a high degree of certainty,[71] and that the fragmented forensic science sector was in need of national oversight.[72]

The portfolio provides a useful case study to explore system perspectives on the competencies of lawyers, judges, and jurors in the context of forensic science evidence. Broadly, case law referencing the portfolio reflects an interaction between scientific knowledge and its application in the criminal justice system; providing insight into how system agents handle scientific knowledge offer by revered bodies that harness interdisciplinary expertise to investigate and report on issues of societal interest. More specifically, such case law is likely to be addressing a point of controversy and/or contention about forensic science evidence and therefore involve comment on the competencies of judges, lawyers and jurors involved in the case — directing and/or reflecting on their past, present and/or future decision-making. It also means case law involving a broad range of forensic science disciplines can be considered, and that approaches across a substantial time period — 30 years (1992 — 2022) — can be evaluated.

Approach

Shooter's study of references to the portfolio in US appellate case law in criminal proceedings, located through application of search terms on Westlaw US, analysed 644 published decisions between 1992 and 2017.[73] Following the application of a consistent analytical framework to each decision — referencing information, case facts, judicial decision, report specific engagement, legal process drivers[74] — she found decisions were characterised by "fidelity to the legal process vision through four principles: the dominance of precedent; deference to institutional settlement; pursuit of finality; and fidelity to the rationality assumption."[75] Her main conclusion was that "legal cultural

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65 *Id.,* at 55.

66 *Strengthening*, *supra* note 2, at xix ("Recognizing that significant improvements are needed in forensic science, Congress directed the National Academy of Sciences to undertake the study that led to this report.")

67 *Id* at 136- 144.

68 *Id* at 150 -156.

69 *Id* at 174- 177.

70 *Id* at 156-162.

71 *Id* at 7.

72 *Id* at 80-83.

73 Shooter, *supra* note 34, at 7.

74 *Id* at 70.

75 *Id* at 7-8.

norms and scientific progress can be reconciled through developing legal actors' forensic science knowledge…" [76]

For this study, we interrogated Westlaw US using the same search terms but expanded the analysis window to cover 1992 to 2022; generating a total of 785 decisions.[77] We then harnessed Shooter's analytical framework to explore how the competencies of trial judges, lawyers and jurors emerged in the data-set. Our methodology — content analysis — is well described by Hall and Wright, "Using this method, a scholar collects a set of documents, such as judicial opinions on a particular subject, and systematically reads them, recording consistent features of each and drawing inferences about their use and meaning."[78] This approach "is more than a better way to read cases. It brings the rigor of social science to our understanding of case law, creating a distinctively legal form of empiricism."[79] We share some key findings from our analysis in Part III.

PART III: FINDINGS: STRATEGY, PRECEDENT, AND WEIGHT

Our analysis confirmed that lawyers, judges, and jurors have distinct and well-defined competencies in criminal proceedings involving forensic science, and that appellate courts will generally defer to their original decision-making or — in some other way — emphasise their competence when reviewing decisions. The following sections — categorised by agent — share key findings, with examples taken from across decades, forensic disciplines, and jurisdictions.

Lawyers

Lawyers monopolise trial proceedings in that they select, present, and challenge forensic science evidence. The decisions lawyers make in exercising these competencies are crucial, and our analysis shows — upon review — they will be afforded considerable deference.

In particular, case law shows decisions around cross-examination strategy are crucial, following Shooter's finding that "… cross-examination is given significant weight by appellate judges."[80] We provide various examples, starting with DNA. The admissibility of certain DNA analysis techniques ——particularly PCR in the 1990s — has been challenged frequently.[81] In response, courts have stressed the importance of cross-examination in determining the probative value of evidence; considering, for instance, issues concerning contamination and misuse of DNA evidence to be an "'open field' for cross-examination."[82] In finding that PCR-DNA evidence satisfied

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[76] *Id* at 8.

[77] Full case list on file with authors.

[78] Mark A. Hall & Ronald F. Wright, *Systematic Content Analysis of Judicial Opinions*, 96 CAL. L. REV. 63, 64 (2008)

[79] *Id.*

[80] Shooter, *supra* note 34, at 214.

[81] *See, e.g.*, discussion in People v. Amundson, 41 Cal. Rptr. 2d 127 (Cal. Ct. App.), as modified (May 16, 1995), review granted and opinion superseded, 899 P.2d 896 (Cal. 1995). In such cases, petitioners generally sought to challenge the admission of DNA evidence prepared via PCR method, as only RFLP analysis had been recommended in *DNA Technology in Forensic Science.* Other challenges prior to the publication of *The Evaluation of Forensic DNA Evidence* questioned the admissibility of alternative was to calculate random match probability, particularly the product rule, as seen in decisions such as People v. Soto, 35 Cal.Rptr.2d 846, 853 (Cal. Ct. App. 1994).

[82] *Id* at 134.

Daubert, as part of a *in limine* application, a New York US District Court in **United States v Cuff**,[83] for example, commented that concerns about forensic DNA evidence were "grist for cross-examination…"[84] Equally, courts have allowed appeals where a trial court has improperly limited a lawyer's strategy to cross-examine DNA evidence. For instance, in **Williams v State**,[85] a Maryland appeals court found the trial court had erred in restricting defense counsel's cross-examination concerning "testing errors and possible spill-over contamination in the lab."[86]

Challenges concerning so-called "soft"[87] forensic science disciplines have also attracted comments that underscore the importance of cross-examination. In **Rodriguez v State**,[88] the Supreme Court of Delaware found a trial court did not abuse its discretion in finding that a latent fingerprint examiner qualified as an expert in the analysis of tire tracks and shoe prints. The Supreme Court reasoned that by "probing [the fingerprint examiner] on his particular experience in tire track and shoeprint analysis…."[89] defense counsel had "challenged his credibility before the jury and the weight to be given the impression evidence."[90] The opportunity to cross-examine was key, as "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…."[91] The court also noted their decision was consistent with other jurisdictions.[92] Similarly, in **Garrett v Commonwealth,**[93] the Supreme Court of Kentucky rejected an appeal that argued — with reference to *Strengthening* — that individualisation testimony by the state's firearms expert was unreliable.[94] The court stated "The proper avenue … to address …concerns about the methodology and reliability … was through cross-examination, as well as through the testimony of his own expert. In this way, the jury was presented with both parties' positions, and with any limitations to the testimony…"[95] Further, in **United States v McCluskey**,[96] a US District Court in New Mexico

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[83] United States v. Cuff, 37 F. Supp. 2d 279 (S.D.N.Y. 1999)

[84] *Id* at 283.

[85] Williams v. State, 342 Md. 724(Md. 1996), disapproved of by Wengert v. State, 364 Md. 76(Md. 2001) (but not in relation to the PCR issue)

[86] *Id* at 749.

[87] Sarah Lucy Cooper, *Forensic Science Identification Evidence: Tensions Between Law and Science,* 16 JOURNAL OF PHILOSOPHY, SCIENCE & LAW 1 (2016). ("[T]he soft sciences comprise disciplines that interpret human behaviour, institutions and society on the basis of investigations for which it can be difficult to establish such levels of precision.")

[88] Rodriguez v. State, 30 A.3d 764, (Del. 2011).

[89] *Id.* at 770.

[90] *Id*.

[91] *Id.* citing Daubert v. Merrell Dow Pharm, Inc. *supra* note 15, at 595–96.

[92] Rodriguez, *supra* note 88, at 770.

[93] Garrett v. Commonwealth, 534 S.W.3d 217 (Ky. 2017), as modified (Dec. 20, 2017).

[94] *Id.* at 222.

[95] *Id.* at 223.

[96] United States v. McCluskey, No. CR 10-2734 JCH, 2013 WL 12335325 (D.N.M. Feb. 7, 2013).

dismissed a challenge to the admissibility of firearms evidence on the basis that defense counsel had the opportunity to cross-examine the expert about their methods and conclusions.[97]

As with DNA evidence, some courts have found it improper to limit cross-examination i.e., disrupt a lawyer's cross-examination strategy, in cases involving soft forensic sciences. For instance, in **State v Harper**,[98] defense counsel wanted to cross-examine the state's firearms expert using the *Ballistic Imaging* (2008) report, but the trial court excluded the report. The state later conceded — and a Wisconsin appeal court agreed — that this restriction on cross-examination was an error.[99] Yet, the appeal court found, even without *Ballistic Imaging* (2008) "trial counsel was able to effectively cross-examine"[100] the ballistics evidence. Indeed, the idea that effective cross-examination can occur absent authoritative scientific literature, also manifested in **State v Fields.**[101] In that case, the Superior Court of New Jersey found that a trial court had correctly decided that *Strengthening* did not qualify as a "learned treatise"[102] and, therefore, had also correctly determined that defense counsel could not cross-examine the state's forensic expert using the report to explore the limitations of fingerprint evidence.[103] These sorts of decisions underscore the need for lawyers to have a thorough scientific understanding of forensic evidence. Lawyers need to be prepared for all eventualities, be that to make compelling arguments as to why scientific literature is needed to support cross-examination, or to carry out effective cross-examination without it.

Decisions by counsel not to cross-examine or perform limited cross-examination will also attract deference. For instance, in **United States v Berry**,[104] the petitioner alleged CBLA evidence presented against him at trial rendered proceedings "fundamentally unfair."[105] In rejecting the claim, the Ninth Circuit Court of Appeals "acknowledged the questionable nature of the [CBLA] evidence"[106] but stated it was for counsel to exercise "the normal adversary process to expose any flaws in the science."[107] In the court's view, criticisms of such evidence are "precisely the kind of evidence that the adversary system is designed to test. Vigorous cross-examination would have exposed its flaws to the jury."[108] This perspective was captured by the Fourth Circuit Court of Appeals

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97 *Id.* at *3.

98 State v. Harper, 821 N.W.2d 412 (Wis. Ct. App. 2012).

99 *Id.* at *2.

100 *Id.* at n5.

101 State v. Fields, No. A-4815-13T3, 2017 WL 1955254 (N.J. Super. Ct. App. Div. May 11, 2017).

102 *Id.* at *5 (In general, "learned treatises are inadmissible hearsay when offered to prove the truth of the matter asserted therein because the author's out-of-court statements are not subject to cross-examination." *Jacober v. St. Peter's Med. Ctr.*, 128 N.J. 475, 486 (1992). Although learned treatises are "inadmissible as substantive evidence, [they] may be used to impeach the credibility of witnesses on cross-examination.")

103 *Id.* at 5-6.

104 United States v. Berry, 624 F.3d 1031 (9th Cir. 2010).

105 *Id.* at 1039.

106 *Id.* at 1040.

107 *Id.*

108 *Id.*

in **United States v Higgs,**[109] when explaining why defense counsel had not been ineffective in confronting the CBLA evidence in the case.

We have found, as Professor Murphy describes, "[a]s currently configured, our [criminal justice] system . . . heavily depends upon the skill of counsel and in-court confrontation . . . ."[110] Edmond *et al* have noted this in the context of forensic science previously, finding, as we have, cross-examination to be an important consideration for appellate courts resolving concerns.[111] Cooper has argued previously that this institutional configuration and judicial practice is symptomatic of the criminal justice system's loyalty to finality:

> "By focusing on the role of defense counsel (and the adversarial system) as a basis for rejecting such appeals [claims based on concerns related to the reliability of forensic science evidence), the courts have been drawing upon an "instrumental" value of finality; namely, incentivizing defense counsel to prevent errors at trial level."[112]

As such, the need for lawyers to be properly trained and educated in forensic science is crucial to their strategic role. Views on the usefulness of cross-examination are mixed, with some describing it as "largely futile"[113] and others considering it "the greatest legal engine invented for the discovery of truth…"[114] Regardless, cross-examination is a staple of the adversarial system. As such, as Henderson and Botluk have said, lawyers need to vigorously cross-examine expert witnesses, including cross-examination of scientific principles underpinning their field of expertise, as a primary means to ensure justice.[115] Lawyers need to be equipped to exercise their competencies to the best of their ability, especially in the context of cross-examination. This is especially so considering — in addition to their likely limited scientific knowledge — lawyers are likely to be navigating "limited resources, and a low-impact and/or depleted adversarial arsenal."[116]

Trial Judges

As part of their role of presiding over trial court proceedings, trial judges must decide if expert evidence is admissible, typically through an assessment of the *Daubert* factors.[117] Our analysis

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[109] United States v. Higgs, 663 F.3d 726, 739 (4th Cir. 2011) ("Here, Higgs has failed to demonstrate that defense counsel's handling of the CBLA evidence at trial was constitutionally ineffective simply because counsel did not ferret out the two preliminary studies or present a defense expert armed with the same information. On the contrary, counsel went a long way towards impeaching the uniqueness and homogeneity of lead melts, as well as the overall probative value of the CBLA evidence, demonstrating that counsel was well-versed in the subject and able to obtain important concessions.")

[110] Erin Murphy, *The Mismatch Between Twenty-First-Century Forensic Evidence and Our Antiquated Criminal Justice System,* 87 S. CAL. L. REV. 633, 672 (2014).

[111] Gary Edmond, Simon Cole, Emma Cunliffe & Andrew Roberts, *Admissibility Compared: The Reception of Incriminating Expert Evidence (I.E Forensic Science) in Four Adversarial Jurisdictions,* 3 U. DENV. CRIM. L. REV. 31 (2013)

[112] Cooper, *supra* note 23 at 759.

[113] Jonathan J. Koehler, *If the Shoe Fits they Might Acquit: The Value of Forensic Science* TESTIMONY 8 J. EMPIRICAL LEGAL STUD. 21, 32 (2011).

[114] 5 J. Wigmore, *Evidence* § 1367, at 32 (J. Chadbourn rev. ed.1974).

[115] Carol Henderson & Diana Botluk, *Sleuthing Scientific Evidence Information on the Internet*, 106 J. CRIM. L. & CRIMINOLOGY 59 (2016).

[116] Cooper, *Judicial Responses to Challenges to Firearms-Identification Evidence, supra* note 10 at 487.

[117] *See. Daubert,* supra note 15.

confirms this gate-keeping competency is deep-rooted in legal practice, and trial court decisions will generally be afforded deference upon review.[118]

Loyalty to precedent emerges as integral to this practice. This is evident in the resolution of the admissibility of DNA evidence in the 1990s. A group of cases, published in 1992 and 1993 from several US jurisdictions,[119] evidently formed core precedent in favour of the admissibility of DNA evidence (when accompanied by a deliberately conservative statistical calculation regarding the likelihood of a random match, known as the ceiling principle) as recommended by *DNA Technology in Forensic Science* (1992). These cases were "quickly cited by subsequent courts."[120] Analysis also suggests that "although elements of these decisions have become outdated (particularly following the publication of *The Evaluation of Forensic DNA Evidence)*, they remain strong authorities in support of the admissibility of DNA evidence in general."[121]

Following precedent may not always mean aligning with the portfolio, however. Appellate courts will defer to trial judges making decisions in line with precedent, even where reputable authorities — like NAS reports —demonstrate that scientific thinking is moving on. For example, in **State v Davidson**[122] the petitioner challenged the trial court's decision to *inter alia* admit fingerprint evidence against him, citing reliability concerns set out in *Strengthening*. In finding no error, the Supreme Court of Kentucky noted that the trial court relied "heavily on the facts "that fingerprint analysis has been used by law enforcement for approximately 100 years and that the rate of error is extremely low.""[123] *Strengthening* had reported zero error-rates to be clearly "unrealistic"[124] and more research was needed.[125] Similarly, in **State v Hoff***,*[126] a petitioner cited *Strengthening* to argue a trial court erred in admitting fingerprint evidence against him. In rejecting the appeal, the Court of Appeals in North Carolina stated "Our Supreme Court has long recognized the validity of fingerprint analysis… This well-established precedent is controlling on defendant's admissibility argument…Given our Supreme Court's long-standing acceptance of the reliability of fingerprint evidence, defendant would not have been entitled to exclude the expert testimony…"[127] The trial court had followed precedent.

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[118] Shooter, *supra* note 34, at 126.

[119] *See,* People v. Barney, 8 Cal.App.4th 798, 814 (Cal. Ct. App. 1992); United States v. Bonds, 12 F.3d 540 (6th Cir. 1993); State v. Bible, 175 Ariz. 549 (Ariz. 1993); Nelson v. State, 628 A.2d 69 (Del. 1993); Commonwealth v. Lanigan, 413 Mass. 154 (Mass. 1993); State v. Vandebogart, 136 N.H. 365 (N.H. 1992); State v. Cauthron, 120 Wash.2d 879 (Wash. 1993).

[120] Shooter, *supra* note 34, at 94.

[121] *Id.* at 102.

[122] State v. Davidson, No. E2013-00394-CCA-R3DD, 2015 WL 1087126 (Tenn. Crim. App. Mar. 10, 2015), aff'd in part, vacated in part, 509 S.W.3d 156 (Tenn. 2016).

[123] *Id.* at 28.

[124] Strengthening, *supra* note 2, at 143.

[125] *Id.* at 144-45.

[126] State v. Hoff, 736 S.E.2d 204 (N.C. Ct. App. 2012).

[127] *Id.* at 209.

Another example relates to microscopic hair analysis. In **Meskimen v Commonwealth**,[128] the petitioner claimed such evidence should not had been admitted against him at trial. The Supreme Court of Kentucky acknowledged — and the petitioner referenced — that microscopic hair analysis had been criticised in *Strengthening* and by the FBI.[129] However, in rejecting the appeal, it noted that the state "offered evidence that has been admissible in the state of Kentucky for many years…."[130] and they would not "disturb the decisions of the trial court without a clear showing of abuse of discretion."[131] The court determined that the decision of the trial court to dispense with a *Daubert* hearing and take judicial notice that hair comparison evidence is scientifically reliable was not an error.[132] Citing its own precedent, the Kentucky Supreme Court said there was no need to "reinvent[ing] the wheel every time by requiring the parties to put on full demonstrations of the validity or invalidity of methods or techniques that have been scrutinized well enough in prior decisions…"[133] Despite this, the court recognised the changing nature of science. It acknowledged that "the state of scientifically accepted evidence is ever changing, and what is scientifically acceptable today may be found to be incorrect or obsolete in the future."[134] As such, judicial notice in context was not "set in stone."[135] In so holding, the court underscored the competency of trial judges to monitor this:

> "It is up to the trial courts to stay abreast of currently accepted scientific methods, as they are the gatekeepers for the admissibility of evidence. Therefore, even though case law may be in acceptance of a certain method of analysis, it is the trial court's duty to ensure that method is supported by scientific findings, or at least not seriously questioned by recent reputable scientific findings…"[136]

Even where appellate courts find error, trial courts' fidelity to precedent emerges as integral. One example is **State v Alt.**[137] In that case, the Court of Appeals of Minnesota concluded the statistical frequencies of individual loci should be admitted alongside evidence of a DNA match, if calculated according to the modified ceiling principle set out in *DNA Technology in Forensic Science* (1992), and that the trial court had erred in excluding such evidence. Consideration of judicial precedent on the issue was key. The court stated, "Several courts have strongly suggested that statistical probability evidence as calculated by means of the NRC modified ceiling principle … should

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[128] Meskimen v. Com., 435 S.W.3d 526 (Ky. 2013).

[129] *Id.* at n9.

[130] *Id.* at 535.

[131] *Id.*

[132] *Id.* at 535-36.

[133] *Id.* at 535.

[134] *Id.*

[135] *Id.*

[136] *Id.*

[137] State v. Alt, 504 N.W.2d 38 (Minn. Ct. App. 1993), review granted in part, cause remanded, 505 N.W.2d 72 (Minn. 1993).

be admitted…"[138] and noted the Washington Supreme Court had considered the NAS' adoption of the methodology as indicative of "general acceptance."[139]

Another example is **State v Roman Nose,**[140] where the Supreme Court of Minnesota found a trial court had improperly denied a petitioner a hearing on the general acceptance of the PCR-STR method of testing DNA. For the court, this was generally a matter of precedent, not science. The state used decisions of other appellate courts to uphold admission of the DNA evidence obtained from PCR-STR testing to argue that a hearing on general acceptance was unnecessary.[141] The Supreme Court of Minnesota found, however, those decisions were not dispositive.[142] This was on the basis that different standards were applied across jurisdictions and the appellate decisions affirming admissibility generally followed a hearing at trial level.[143] As such, to follow them "would be a departure from our precedent requiring a ... hearing."[144] The court remanded the case back to the trial court to exercise its competency at such a hearing,[145] showing deference to the trial court's competence. This same can be seen in **State v Celaya**.[146] In that case, the Arizona Court of Appeals found that the trial court's refusal to admit evidence discrediting firearms evidence based on *Strengthening* may have amounted to plain error, but referred the question of admissibility back to the lower court for an evidentiary hearing.[147]

We have concluded previously that there is an institutional "commitment to precedent"[148] and that "precedent is the biggest driving force behind [judicial] decision- making."[149] Precedent is relied upon by courts to "resolve and neutralize"[150] concerns about the reliability of forensic science. Judges have recognised this too, and associated pitfalls. As Judge Jed S. Rakoff has said regarding the general acceptance standard:

> "A lot of U.S. law is judge-made law, and that requires very heavy attention to stare decisis, to precedent … That is built into the system, and there are a lot of positive things to be said for it, but in this area, it operates very negatively because all of the precedents allowing in

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[138] *Id.* at 50.

[139] *Id*.

[140] State v. Roman Nose, 649 N.W.2d 815 (Minn. 2002).

[141] *Id.* at 820 ("The state points to the decisions of other appellate courts that have upheld admission of DNA evidence obtained from PCR-STR testing to argue that a *Frye-Mack* hearing on general acceptance of the PCR-STR method is unnecessary.")

[142] *Id.* At 821 ("However, we have not decided general acceptance for Minnesota courts.")

[143] *Id.* at 820- 821.

[144] *Id.* at 823.

[145] *Id.* at 820.

[146] State v Celaya 2014 WL 4244049 (Court of Appeal of Arizona 2014).

[147] *Id.* at *7.

[148] Sarah Lucy Cooper, *Forensic Science Developments and Judicial Decision-Making in the Era of Innocence: The Influence of Legal Process Theory and Its Implications*, 19 RICH. J.L. & PUB. INT. 211, 226 (2016) ("the American common law system's commitment to the principle of *stare decisis.")*

[149] Shooter, *supra* note 34, at 116.

[150] Cooper, *Challenges to Fingerprint Identification Evidence, supra* note 23 at 759. (Commenting in the context of fingerprinting).

all this stuff were set during a time when Frye applied, and in which Frye was not really taken seriously, and so almost anything came in."[151]

The organisation of the criminal justice system means courts (and not the scientific community) determine "good science."[152] As such, judges need to be equipped with relevant scientific understanding. Jasanoff has proposed that judges need a better understanding of scientific evidence and its underlying principles to make informed gatekeeping decisions.[153] In particular, they need to be equipped "to interrogate the usefulness of precedent more closely, and not allow the passage of time to dictate scientific validity and reliability."[154]

Jurors

Jurors must determine the weight of forensic science evidence. Appellate courts defer widely to this competence when dealing with challenges to such evidence, broadly finding that reliability challenges are a matter of weight not admissibility. This "highlights the defined nature of the jury, showing their broad competence and discretion to determine the weight of evidence within the trial process, even if evidence has significant limitations."[155] What we see clearly across these cases, too, is the layering of competencies — appellate courts simultaneously make points about associated competencies of lawyers and trial courts.

This approach is evident from the 1990s in cases concerning DNA evidence. For instance, in **State v Peters**,[156] Peters challenged the reliability of DNA evidence against him, specifically probability calculations used by the FBI. In finding no error by the trial court, the Court of Appeals of New Mexico noted that the state's expert had defended his calculations on both cross and direct examination, and cited state precedent that had held "questions about the accuracy of results goes to the weight of the evidence and is therefore a jury question."[157] **People v Lee**[158] is another example. The trial court had admitted DNA evidence obtained using PCR analysis against Lee. Lee challenged this, arguing PCR was not appropriately validated. The Court of Appeals of Michigan disagreed, citing precedent to support a holding that "trial courts in Michigan may take judicial notice of the reliability of DNA testing using the PCR method."[159] It warned, however, of measures to be taken by trial courts and lawyers to support juries in their determinations of weight. Before admitting such evidence, a trial court must ensure the prosecutor has shown "generally accepted laborat-

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[151] The Honorable Jed S. Rakoff, Keynote Address: *"Judging Forensics" Remarks and Q&A Session*, 6 VA. J. CRIM. L. 29, 38 (2018)

[152] John B. Meixner, Shari Seidman Diamond, The Hidden Daubert Factor: How Judges use Error Rates in Assessing Scientific Evidence, 2014 WIS. L. REV. 1063, 1080 (2014).

[153] Sheila Jasanoff, Research Subpoenas and the Sociology of Knowledge, 59 LAW & CONTEMP. PROBS. 95 (1996).

[154] Cooper, *supra* note 87, at 23.

[155] Shooter, *supra* note 34, at 183.

[156] State v. Peters, 944 P.2d 896 (N.M. Ct. App. 1997).

[157] *Id* at 903.

[158] People v. Lee, 537 N.W.2d 233 (Mich. Ct. App. 1995).

[159] *Id* at 257-258.

ory procedures were followed."[160] Furthermore, in the course of expert testimony, the inherent limitations of PCR testing should be "made clear to juries"[161] and "care [should] be taken" to help jurors not confuse PCR and RFLP methods and understand relevant "probative limitations."[162] Although the appeal court did not explicitly nominate lawyers for these tasks, they fall obviously within the remit of direct and cross-examination.

Similar approaches are evident beyond DNA evidence. For example, in **Commonwealth v Joyner**,[163] Joyner argued the testimony of the state's fingerprint expert was insufficient because the expert "provided no standard by which he measured the comparison or the probability that the fingerprints came from the same source."[164] In support, Joyner cited precedent arguing that the state may not introduce evidence of a DNA match or non-exclusion without accompanying statistical evidence.[165] The Supreme Judicial Court of Massachusetts found this use of precedent "inapposite"[166] — those cases addressed *admissibility* (which was not in question), not *sufficiency*.[167] Instead, the court cited precedent that underscored the competency of the jury and counsel in such instances. This included the court's decision in a 1977 case, **Commonwealth v Lacorte:**

> ""it is for the jury to determine—after listening to cross-examination and the closing arguments of counsel—what significance, if any, they will attach to the discovery of the defendant's fingerprints at the scene of the crime."[168]

Jurors must use permitted information to weigh forensic science evidence. Deference to lawyering and trial court competencies are evident in this context too. For example, case law underscores cross-examination is a preferred vehicle to provide critical information to jurors, even if it was unarmed with current knowledge. For instance, in **Commonwealth v Lykus**,[169] a Superior Court of Massachusetts found that *Forensic Analysis: Weighing Bullet Lead Evidence* (2004) was new evidence, requiring a new trial. It determined that if the report had been available to the jury at the time of the defendant's trial it "almost certainly would "probably have been a real factor in the jury's deliberations.""[170] Yet, this decision was overruled, with a subsequent court finding *inter alia* that the report contained "the same kind of evidence elicited on cross-examination"[171] of the relevant witness. Where jurors bring unauthorised information into a trial, outcomes from that trial may

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[160] *Id* at 258.

[161] *Id*.

[162] *Id*.

[163] Com. v. Joyner, 4 N.E.3d 282 (Mass. 2014).

[164] Id at 290-291.

[165] *Id* at 291.

[166] *Id*.

[167] *Id*.

[168] *Id* (citing to Com. v. LaCorte, 369 N.E.2d 1006, 1008 (Mass. 1977)).

[169] Com. v. Lykus, No. 43558, 2005 WL 3804726 (Mass. Super. Dec. 30, 2005).

[170] *Id.* at *18.

[171] Com. v. Lykus, 885 N.E.2d 769, 784 (Mass. 2008).

be illegitimate. This was the case in **People v Pizarro,**[172] where a juror read an earlier court decision in the defendant's case, which included details about forensic DNA evidence not included in the instant proceedings. The trial court had denied a new trial, however the review court determined that the juror had "made a mockery of the trial process"[173] and a reversal of the trial court's decision to not allow a new trial was warranted. Yet, even in making this decision, the reviewing court made several express statements in support of the trial court's decision-making:

> "We sympathize with the trial judge who, having presided over two jury trials and a prolonged …hearing amid two appeals, was called upon to make the difficult decision of whether to grant yet another new trial in a case that was then almost 20 years old. The trial court ultimately denied defendant's new trial motion, finding it to be a "close case" and a "real hard, hard decision to make." While we agree with the trial judge that the juror misconduct in this case amounted to "gross misconduct" and was "absolutely outrageous," we disagree with his decision denying the new trial motion."[174]

The courts' routine deference to the jury's decision-making competence has been linked to the criminal justice system's loyalty to legal process theory.[175] The scope afforded to jurors in evaluating forensic science has been subject to criticism.[176] The vast majority of jurors are not scientists.[177] They may have a "thirst" for scientific evidence[178] and expect to see it particularly in cases where the majority of evidence is circumstantial.[179] Their expectations of science may be inflated too,[180] with some finding that jurors are easily influenced by testifying experts,[181] and place special trust in scientific evidence.[182] Jurors may find expert testimony confusing, especially statistical evidence,[183] and, therefore, may also find judging the weight to be afforded scientific evidence a challenging exercise. That said, "research has demonstrated a consistency between jury and bench

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172 People v. Pizarro, 158 Cal. Rptr. 3d 55 (Cal. Ct. App. 2013), as modified on denial of reh'g (June 13, 2013).

173 *Id.* At 60.

174 *Id.* at 59.

175 See, for example, Cooper, *supra* notes 10, 23, 87 & 148.

176 *See, e.g.,* Ryan McDonald, *Juries and Crime Labs: Connecting the Weak Links in the DNA Chain,* 24 AM. J. L. & MED. 345 (1998)*;* David H. Kaye, Valerie P. Hans, B. Michael Dann, Erin Farley, *Statistics in the Jury Box: How Jurors Respond to Mitochondrial DNA Match Probabilities,* 4 J. EMPIRICAL LEGAL STUD. 979 (2007); Dale A. Nance, Scott B. Morris, *Juror Understanding of DNA Evidence: An Empirical Assessment of Presentation Formats for Trace Evidence with a Relatively Small Random Match Probability* 34 J. LEGAL STUD. 395 (2005).

177 Faigman, *supra* note 19, at 53.

178 Donald E. Shelton et al., *A Study of Juror Expectations and Demands Concerning Scientific Evidence: Does the "CSI Effect" Exist?*, 9 VAND. J. ENT. & TECH. L. 331, 333 (2006).

179 Pete Frick, *Forensic Science in Court: Challenges in the Twenty-First Century*, 27 SYRACUSE J. SCI. & TECH. L. 145, 156 (2012).

180 Dawn McQuiston-Surrett & Michael J. Saks, *Communicating Opinion Evidence in the Forensic Identification Sciences: Accuracy and Impact,* 59 HASTINGS L.J. 1159, 1188 (2008).

181 See Simon Cole, *Grandfathering Evidence: Fingerprint Admissibility Rulings From Jennings to Llera Plaza and Back Again*, 41 AM. CRIM. L. REV. 1189 (2004) (general proposition that jurors are easily seduced).

182 Brandon Garrett & Peter Neufeld, *Invalid Forensic Science Testimony and Wrongful Convictions*, 95 VA. L. REV. 1, 32 (2009).

183 McQuiston-Surrett & Saks, *supra* note 180, at 1189. Also see *Strengthening*, *supra* note 2, at 236-237.

trial verdicts, regardless of the level of scientific complexity involved."[184] There is also evidence that jurors raise appropriate concerns about forensic evidence,[185] deliver generally justified outcomes,[186] and that errors in juror interpretation may well be "traceable in part to misleading presentations and instructions by attorneys and judges."[187] This suggests, like our analysis, that the competencies of lawyers, judges and jurors are interdependent.

PART IV: CONCLUSIONS: CONCEPTUALISING SCIENCE LITERACY FOR LAWYERS

Lawyers, trial judges, and jurors form part of the fabric of the criminal justice system. An overhaul of the system's deep reliance on them to properly discharge their competencies in cases involving forensic science (or any other case for that matter) is very unlikely. They are the hands through which the criminal justice system aims to achieve justice — legitimate and accurate outcomes, public confidence and, thus, the maintenance of social order. Calls to "educate the users of forensic science analyses, especially those in the legal community…"[188] have been made far and wide, including by the NAS, PCAST,[189] and American Bar Association.[190] Several considerations are foundational to determining an education and training provision that equips key agents with the scientific understanding they need. We present two.

First is a consideration of who should be prioritised, and our recommendation is that lawyers' needs are targeted. Lawyers make key calls about forensic science evidence at all stages of its journey through the criminal justice system — its selection, how it is presented and challenged, and what role it plays in a case narrative. Moreover, lawyers become judges, who then make other key calls, for instance about what precedent to follow and/or shape regarding admissibility, the boundaries of direct and cross-examination, and the tools lawyers can use in both pursuits. 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 optimised, 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. Theoretically. The case law in Part III (*Jurors*) suggests this is an idea to which the criminal justice system is already expectant. Furthermore, lawyers are intended to be permanent, frequent, and expert players in the system, which stands in stark contrast to jury service, which is temporary, infrequent, and entirely intended to bring a "lay" perspective to matters. Although the idea of jurors being lay members in proceedings is a staple of the justice system, to counter their lack of specific scientific knowledge, the idea of "science-quali-

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184 *Strengthening*, *supra* note 2, at 236.

185 *Id.* At 237.

186 *Id.* at 236.

187 *Id*.

188 *Id.* at 218.

189 *See generally,* Executive Office of the President, President's Council of Advisors on Science and Technology, Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature Comparison Methods (Executive Office of the President Of The United States 2016).

190 Brandon L. Garrett et. al., *Forensic Science in Legal Education*, 51 J.L. & Educ. 1, 12 (2022).

fied" and/or "rational" juries has been mooted.[191] Lawyers also have a generally uniform education pathway and established professional associations, which provide potential spaces (e.g., Law School) to deliver science education and training, albeit there are notable challenges.[192] Lawyers are also bound in disciplinary cultures and norms that obligate, expect and/or value expertise, continuing professional development (CPD), and ethical and effective performance, which should motivate engagement with development opportunities and offer frameworks (like CPD) to scaffold them. Moreover, the influence of lawyers can go beyond individual cases, as there is scope for them to bring their expertise to wider issues of, for instance, legal policy, law-making, education.

Second is to consider the existing provision of scientific education for lawyers.[193] Programs[194] and literature have been developed,[195] as have ideas for "customized training."[196] Some law schools offer access to forensic science education.[197] The National Commission on Forensic Science (NCFS), which was established in 2013, had a dedicated Training in Science and Law subcommittee that: "explored mechanisms … to ensure that legal professionals understand the probative value and limitations of forensic science …"[198] and offered several recommendations before the NCFS was disbanded in 2017.[199] Following an evaluation of the concerns raised in *Strengthening,*[200] the National Institute of Scientific Standards launched the Organization of Scientific Area Committees (OSAC) for Forensic Science,[201] which aims to "strengthen the nation's use of forensic science by facilitating the development and promoting the use of high-quality, technically sound standards."[202] These standards, which are publicly available, are of relevance and

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191 *See, e.g.,* Pooja Chaudhuri, A Right To Rational Juries? How Jury Instructions Create The "Bionic Juror" In Criminal Proceedings Involving DNA Match Evidence 105 CALIF. L. REV. 1807 (2017); Confronting the New Challenges of Scientific Evidence, *supra* note 20.

192 *Science Literacy:supra* note 11, at 111 ("Education systems provide opportunities to develop science literacy and that the structures within these systems may enable or constrain the development of science literacy…"); Also see Garrett et al, *supra* note 190.

193 For a comprehensive provision overview, see, Amy Evans, Charles Kim, Nicholas Laraia, Zachary Lutz, Allison Osborne, Emily & Parchuke, Loren Williams, Alicia Zook, Lawrence Quarino, *Toward A More Effective Use and Understanding of Forensic Evidence in Courts of Law: Developing Strategies for the Scientific Education of Legal Practitioners*, 25 WIDENER L. REV. 1 (2019).

194 Id. See generally, *Strengthening*, supra note 2, at 234- 236. Organisations such as The Forensic Institute provide training to legal professionals, and conduct work across the UK, USA and Canada. See, The Forensic Institute, Training, Seminars and Conferences, http://www.theforensicinstitute.com/training (last visited August 30, 2022); The National Courts and Sciences Institute also provides training for legal professionals. See, Welcome to the National Courts and Sciences Institute, https://www.courtsandsciences.org/ (last visited August 30, 2022).

195 *Id*. *Also see*, Paul S. Miller, *Daubert and the Need for Judicial Scientific Literacy*, 77 JUDICATURE 254 (1994). The American Bar Association publishes material designed to support lawyers' knowledge of forensic science and its application. *See,* DP LYLE, ABA FUNDAMENTALS: FORENSIC SCIENCE, (ABA Book Publishing 2012).

196 *Strengthening*, *supra* note 2 at 234 – 235.

197 *Id*.; Garrett *et al.*, *supra* note 190; Evans *et al*, *supra* note 194.

198 *See*, The United States department of Justice Archives, *Training on Science and Law,* https://www.justice.gov/archives/ncfs/training-science-and-law (last visited August 30, 2022).

199 *Id*.

200 Redle & Plourd, *supra* note 3, at 58. ("The Organization of Scientific Area Committees (OSAC) for Forensic Science can trace its origins back to the 2009 report of the National Academy of Sciences Strengthening Forensic Science in the United States: A Path Forward…").

201 NIST, *NIST Launches an Updated Organization of Scientific Area Committees For Forensic Science* (October 1, 2020) https://www.nist.gov/news-events/news/2020/10/nist-launches-updated-organization-scientific-area-committees-forensic (last visited August 30, 2022).

202 NIST, *The Organization of Scientific Area Committees for Forensic Science,* https://www.nist.gov/organization-scientific-area-committees-forensic-science (last visited August 30, 2022).

support to legal professionals,[203] yet there are barriers to engagement.[204] Generally, concerns exist about the lack of mandatory, continuing, and assessed training on offer to lawyers.[205] Evidently, although a considerable patchwork of support is on offer, there remains more to do in terms of developing a joined-up provision that meets, to the fullest extent possible, all relevant complexities and needs.

Science Literacy

Our suggestion is that generating greater understanding of lawyers' base position, namely their 'science literacy' — "the disposition and knowledge needed to engage with science…."[206] is foundational to developing such provision. The benefits of fostering science literacy across society broadly have been recognised,[207] as have they for legal professionals specifically.[208] Faigman and Lesikar, for example, have wrote "The 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…."[209] and Caudill has explored science literacy specifically in the context of judges as public actors.[210] Similar references extend to several legal issues, including education,[211] technology,[212] the

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[203] Redle & Plourd, *supra* notę 3.

[204] *Id*. ("Most standards are voluntary in that they are offered for adoption by people or industry without being mandated in law.").

[205] *Strengthening, supra* note 2 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.")

[206] *Science Literacy*, *supra* note 193, at 27 ("The phrase was coined as a means of expressing the disposition and knowledge needed to engage with science— both in an individual's personal life and in the context of civic issues raised by both the use of science and technology and the production of more knowledge.")

[207] *Science Literacy*, *supra* note 193, at 22-26.

[208] *See, e.g.,* Edward K. Cheng, Independent Judicial Research in the Daubert Age, 56 DUKE L. J. 1263, 1273 (2007) (" Judicial education programs are a sound step toward improving the ability of judges to handle scientific evidence"); Jules Epstein, Preferring the Wise Man to Science: The Failure of Courts and Non-Litigation Mechanisms to Demand Validity in Forensic Matching Testimony, 20 WIDENER L. REV. 81, 83-4 (2014) ("The failure to re-examine and respond to the question ofvalidation may be attributable to… the lack of scientific training and education among the judiciary, corps of prosecutors, and defense counsellors"). *See generally,* Kenneth R. Kreiling, Scientific Evidence: Toward Providing the Lay Trier with the Comprehensible and Reliable Evidence Necessary to Meet the Goals of the Rules of Evidence, 32 ARIZ. L. REV. 915 (1990).

[209] 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).

[210] David S. Caudill, *Ibsen's an Enemy of the People and the Public Understanding of Science in Law*, 16 Geo. Int'l Envtl. L. Rev. 1 (2003).

[211] James O. Freedman, *Liberal Education and the Legal Profession*, 39 SW. L.J. 741 (1985)

[212] Massimiano Bucchi and Barbara Saracino, "Visual Science Literacy": Images and Public Understanding of Science in the Digital Age 38(6) SCIENCE COMMUNICATION 812 (2016).

environment and public health,[213] consumer choices,[214] and forensic science.[215] Indeed, the NAS has even reported on the need to focus on the science literacy of legal professionals:

> "Participation in particular social systems requires different, perhaps deeper levels of science literacy … citizens participating in the legal system (judges, lawyers, jurors, plaintiffs, defendants) may require different understanding of scientific concepts for justice to be served….[216] [yet] the value of science literacy in societal systems such as the justice system…[has] not been studied in sufficient detail."[217]

There is need to conceptualise science literacy for lawyers, from the perspective of lawyers. The process of conceptualisation requires — basically — the identification of indicators and dimensions (or aspects), the latter being aspects of a concept, which are determined by groups of the former. For instance, statements by lawyers to the effect that holding/not holding scientific qualifications made them more/less able to understand scientific evidence, might be indicators that a dimension of science literacy for lawyers is education. Beyond specific studies suggesting schooling, politics, language skills, and inequalities inform concepts of science literacy,[218] the NAS has collated proposed dimensions of science literacy, namely *Foundational Literacies*, *Content Knowledge*, *Understanding of Scientific Practices*, *Identifying and Judging Appropriate Scientific Expertise*, *Epistemic Knowledge*, *Cultural Understanding of Science*, and *Dispositions and Habits of Mind*.[219] This collation provides a framework ["the framework"] for investigating lawyers' perspectives on science literacy.

Within the framework we suggest the topic of this article — the criminal justice system's consumption of forensic science evidence where the NAS' forensic science portfolio is relevant — would provide a helpful case study through which to engage lawyers. One, it would appropriately focus the research by allowing for a specific group of lawyers — public defenders (as a sub-set of criminal defense lawyers) — to be targeted. This would focus the research design, but also allow for coordinated engagement with a large and diverse research participant base, with a range of experiences and who work within a broadly consistent employment framework. This would maximise the application of outcomes.

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[213] The Ethics of Communicating Scientific Uncertainty, 45 ENVTL. L. REP. NEWS & ANALYSIS 10105 (2015).

[214] Robert C. Bird, *Anti-Gmo and Vaccine-Autism Public Policy Campaigns in the Court of Public Opinion*, 72 HASTINGS L.J. 719, 764 (2021) ("…a consumer's best defense against misleading science is basic scientific literacy…")

[215] Citations have also been made in contexts specific to this article. For instance, references have been made in relation to the trial judge's gate-keeping role under *Daubert.* Paul S. Miller, *Daubert and the Need for Judicial Scientific Literacy,* 77 JUDICATURE 254 (1994) ("To carry out the [Supreme] Court's purpose [in *Daubert*], each federal trial judge must achieve at least a basic level of scientific literacy"). Redle and Plourd, *supra* note 3, provide another example. ("As noted by the NAS report, occasionally American courts have been proven wrong when they face the impenetrable problem of when to admit or exclude new or novel scientific evidence. This dilemma reflects the reality of the scientific illiteracy of lawyers and judges, which renders them unable on their own to decide the admissibility of evidence proffered through expert witnesses correctly.").

[216] *Science Literacy*, *supra* note 11, at 110-111.

[217] *Id* at 110.

[218] *See, e.g.,* Juanita V. Field, *Serendipitous Result Obtained in Developing Science Literacy Course,* 19 IDEA 183 (1977-1978); Noah Feinstein, *Salvaging Science Literacy*, 95(1) SCIENCE EDUCATION 168 (2011); Larry D. Yore, David F. Treagust, *Current Realities and Future Possibilities: Language and Science Literacy Empowering Research and Informing Instruction* 28 INTERNATIONAL JOURNAL OF SCIENCE EDUCATION 291 (2006).

[219] *Science Literacy*, *supra* note 11, at 32-33.

Two, the breadth of legal practice and existing research on the topic should permit exploration of the framework in ways that are timely and relevant to relevant to lawyers. The longevity and diversity of the application of forensic science in criminal proceedings[220] means the case study would align with the NAS' recommendation to focus science literacy research for legal professionals on "fields of science [that] are most frequently referenced in the legal arena."[221] The portfolio also provides a picture of scientific understanding across both a range of individual disciplines and the general forensic science field; meaning reports can be used as, for example, benchmarks as to "what level of understanding of scientific principles, methodologies, and habits of mind are needed"[222] by lawyers. Scholarship highlights possible tensions to interrogate within the framework's dimensions. For example, doctrinal research — like that in this article — demonstrates the criminal justice system has certain 'habits of mind', which might clash with dispositions identified as relevant to science literacy, such as open-mindedness.[223] A loyalty to precedent might, for instance, impinge on such a disposition.

Lawyers play a vital role in the criminal justice system, which is organised to defer widely to their decision-making, a configuration that is unlikely to change. In cases involving forensic science evidence, the law intersects with science, and lawyers may encounter a range of institutional and personal challenges in executing their role. To limit these challenges, stakeholders have recommended scientific education and training for lawyers, recognising that their science literacy is relevant to the system's aim of serving justice. We suggest that conceptualising 'science literacy,' from the perspective of lawyers, is a necessary next step towards this goal.

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220 Cooper, *supra* note 87 at 1 ("For decades, courtrooms around the world have admitted evidence from forensic science analysts, such as fingerprint, tool-mark and bite-mark examiners, in order to solve crimes.")

221 *Science Literacy*, *supra* note 11, at 111.

222 *Id*.

223 *Id* at 33.