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DNA Fingerprinting and Civil Liberties

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Just Evidence: The Limits of Science in the Legal Process

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"Relying on Science, Romney Files Death Penalty Bill."[1] With that headline, a press release on April 28, 2005 announced that Massachusetts Governor Mitt Romney was seeking to reintroduce by legislation the death penalty that the state's Supreme Judicial Court ruled unconstitutional in 1984.[2] The remainder of the text left little doubt that science was a major basis for the governor's action. The press release quoted Romney as saying that the bill provided a "gold standard for the death penalty in the modern scientific age." Positing a symmetry that will be questioned below, Romney also declared, "Just as science can free the innocent, it can also identify the guilty." The bill itself deferred to science by calling for corroborating scientific evidence, multiple layers of review, and a novel "no doubt" standard of proof. By raising the required standard of evidence and by restricting the class of capital crimes, the proposed law hoped to correct the defects of other death penalty statutes. As Romney remarked to the press, "I'm hoping [Massachusetts lawmakers] take a look at this and say 'you know, this removes the major weakness in death penalty statutes in other states.' The weakness in the death penalty statutes in other states, of course, is the fear that you may execute someone who is innocent. *We remove that possibility"* (emphasis added).[3] Most newspaper headlines reporting on the bill, both before and after its introduction, flagged science as the factor most influencing Romney, and quoted his desire for incontrovertible, foolproof evidence.

The governor's faith in the perfectibility of the death penalty reflects modern societies' conviction that science can deliver failsafe, and therefore just, legal outcomes where the law, acting on its own, might fall short. That belief, in turn, owes much to the widely recognized self-corrective nature of science, which is thought to identify mistakes and weed out error more effectively than other social institutions. As the noted American sociologist of science, Robert K. Merton, observed in a 1942 article, "organized skepticism" is one of the distinctive norms of science.[4] Implemented through the practices of peer review, this skeptical stance keeps scientists from accepting each other's results until they conform to communally negotiated standards of truth and objectivity. Merton argued that it is essential in the scientific community to aim for high standards of accuracy because scientists, who build on each other's work, have a collective stake in making their claims reliable and reproducible. Merton saw organized skepticism, as well as three other norms – communalism, universal-

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ism, and disinterestedness – as an institutional imperative of science.

However, when science is used for legal purposes, it cannot be taken for granted that the same institutional imperatives continue to apply. In the legal arena, the context for science changes, and these changes affect the results one can expect from science. The law has its own institutional needs and constraints, and these are broadly geared toward ensuring that justice is done in each individual case. Processes designed to meet the law's primary imperatives are not necessarily well suited to discriminating between good and bad scientific claims; nor is it clear that the law does, or indeed always should, defer to science's overriding commitment to self-correction.

The U.S. Supreme Court attempted in 1993 to forge convergence between science and law in admissibility decisions for scientific expert evidence in federal trials. Trial judges, the Court held in the landmark case of *Daubert v. Merrell Dow Pharmaceuticals, Inc.*,[5] should act, in effect, as surrogates for the scientific community in determining admissibility, and they should do so by applying the same standards that scientists would bring to the assessment of relevance and reliability. But it quickly became clear that the corrective processes that operate within science cannot be reproduced wholesale in legal settings. For example, in *General Electric Co. v. Joiner*,[6] the Court held that a trial judge's admissibility ruling can be reviewed by an appellate court only on grounds of abuse of discretion. This stringent review standard serves the law's interest in repose, by letting stand most trial court decisions, but it also insulates admissibility rulings against the kind of systematic peer skepticism that is routine in science.

The use of scientific evidence such as DNA tests in court thus brings into collaboration two institutions with significantly different aims and normative commitments. In their by no means friction-free encounter, neither science nor law completely retains or completely relinquishes its autonomy. Science done to serve the law cannot proceed in quite the same ways as science done purely to advance the cause of science; and, while turning to science for authoritative input, the law never sets aside its commitment to core values beyond the search for factual accuracy. Lawmakers' expectations of science to simply step in and cure the law's deficiencies, without taking into account the disparate dynamics of the two institutions, are exaggerated (as in Romney's claim that his bill would "remove" the possibility of wrongful executions), and, at the limit, lead to questionable justice.

A starting point for creating a framework of more reasonable expectations for the relationship between law and science is to recognize that science enters the courtroom not in the form of bare facts or claimed truths about the world, but as *evidence*. That is, science must be worked into the particular kinds of propositions, representations, or material objects that the law regards as germane to establishing which party is telling the more plausible story. Scientific and technical evidence presented by expert witnesses, in particular, has to meet a number of criteria specific to the epistemological needs of the law. For instance, it must be relevant, it must be timely, and it must meet the *Daubert* tests of admissibility. This article examines points in the transition from scientific observation to proffered legal evidence at which problems may creep into the production of science for legal uses. DNA evidence is the illustrative example chosen for this purpose, although the analysis of this particular case has broader implications for the law's reliance on science.

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DNA and Truth-Telling

The seventeenth century philosopher and statesman Sir Francis Bacon, a lawyer by training, famously interpreted Pontius Pilate's skepticism about the absoluteness of truth as a moral failing, a deplorable and unprincipled "giddiness." Bacon's essay, "Of Truth," opens with the much quoted line, "What is truth? said jesting Pilate, and would not stay for an answer."[7] Pilate's irresponsibility, Bacon implied, lay not so much in questioning the nature of truth, as in refusing to wait for an answer – as if the truth did not matter even when, as in this case, a man's life was at stake. That man, of course, was Jesus of Nazareth, who had just informed Pilate that his own mission in the world was to be a witness for the truth. Perhaps Pilate's very reluctance to embrace the possibility of a transcendental truth undermined his assertion that he had found no fault in Jesus. At any rate, we know from the Gospels that

Pilate failed to convince his hearers. They demanded the release of Barabbas, a convicted robber, and the crucifixion of Jesus, the self-proclaimed Messiah who stood for the truth. Pilate, the equivocating politician, acquiesced, to his lasting shame.

In our time, the truths that people regard as transcendental concern the workings of nature, and they flow principally from the natural sciences. Biologists today, for example, accept without question the double helical structure of DNA and the chemical composition of the base pairs that make up its two intertwined strands. These are taken as undeniable facts, not contingent in any way on the circumstances of their discovery. It is not considered relevant to our understanding of the basic material of life, nor of the ways in which living things propagate themselves, that the structure of DNA was discovered by two exceptionally talented, young, male scientists, James Watson and Francis Crick, in a laboratory in Cambridge, England, in 1953.[8] The facts that they found are accepted as true, even if the discovery itself was contingent on many specific social and historical circumstances. Science may be a social activity, but when executed correctly, the results are viewed as no longer bearing traces of human subjectivity.

Since the early years of industrialization, belief has grown in legal circles that scientific evidence is one of the most reliable kinds of evidence, and that science can deliver insights into matters otherwise hidden from judicial inquiry.[9] Courts, to be sure, have not jumped to embrace every kind of new scientific or technical evidence, especially when such evidence presumes to determine ultimate issues of guilt or innocence. Thus, in the 1923 case of *Frye v. United States*,[10] the Court of Appeals for the D.C. Circuit announced a criterion of admissibility – the general acceptance test set aside by *Daubert* seventy years later – which excluded testimony based on lie detector tests. Nevertheless, legal actors continue to embrace new technologies that could shed light on matters such as criminal intent, propensity to violence, identity, or truthfulness. In the trial of John Hinckley, the man who shot President Ronald Reagan and others in 1981, the defense sought to introduce brain images as evidence of the defendant's state of mind, arguably at a time when the interpretation of such images had not yet reached the state of "general acceptance." A reluctant trial judge admitted the images, but under conditions that greatly diminished their possible impact on the jury.[11] More generally, the law participates along with other social institutions in "the pervasive tendency to medicalize social problems," that is, "to reduce complex behavior to measurable [and testable] biological dimensions."[12] The push to do so comes as much from within the sciences as from the dynamics of the law. One medical expert in brain imaging, for example, expressed the wish that "medical definitions must replace legal definitions" replacing legal ideas of "sick minds" with depictions of "sick brains."[13]

One reason for society's (and the law's) relative willingness to place trust in science and technology is that technoscientific practices seem to take the establishment of the truth away from fallible human beings like Pontius Pilate, and lodge it instead in various more or less reliable impersonal agents: a diagnostic instrument such as a lie detector or a truth serum; a recording device, such as a camera or a tape recorder; an identification technique, such as fingerprinting; or bits of physical evidence left at the scene by the person charged with committing a crime. The hope is that technology, through its mechanical reproducibility, will be impervious to context and will provide unbiased and reliable evidence about the facts of the matter. Human actions, however, can never be entirely ruled out of the picture in the production of evidence. Physical traces remain silent, and for all practical purposes unreadable, unless they are made to speak with the aid of specialized laboratory techniques, scientific instruments, and expert testimony, all of which demand the work of trained professionals. Thus, fingerprints cannot definitively incriminate a defendant without the aid of a complex social infrastructure to make them visible and interpretable in a court of law.[14] Similarly, even a videotape may need a professional interpreter to explain to the judge or jury how to make sense of the actions that the film purports to show with photographic accuracy.[15] Nevertheless, supplementing human judgment with technological support is a recognized and persuasive means of enhancing the credibility of expert witnesses in legal proceedings.[16]

One of the most powerful techniques ever invented to make physical evidence bear witness in legal proceedings is DNA profiling (or DNA fingerprinting).[17] First developed in the 1980s by Sir Alec Jeffreys, a geneticist at Britain's University of Leicester, the technique compares patterns made by DNA extracted from crime scene samples of blood, hair, or semen with DNA taken from suspects. Because of the distinctiveness of DNA sequences in any given individual, the probability of making an erroneous match is, in most cases, extremely small, although that probability rises when comparing DNA profiles among closely related persons, such as within families or in well-delineated ethnic groups; in the limiting case, identical twins will have the same DNA fingerprint, so that neither twin can be incriminated or exculpated solely on the basis of a DNA match. Despite these caveats, DNA profiling emerged in the final decades of the twentieth century as the nearest

thing to a failsafe method of identification in the toolkit of the forensic sciences. It came close to realizing the prosecutor's dream of a method for revealing a party's guilt or innocence with no possibility of error.

Belief in the near infallibility of DNA profiles has worked in contradictory ways within the US political process. On the one hand, it led the civil rights lawyers Barry C. Scheck and Peter J. Neufeld to found the widely acclaimed Innocence Project, a legal clinic that uses DNA evidence to exonerate wrongfully convicted persons. Established in 1992, the project had succeeded in exonerating 172 mostly indigent prisoners by early 2006, sometimes after years of incarceration.[18] It has given renewed force to anti-death penalty activists who had been blocked for years by political and judicial opposition to their cause. If, as the Innocence Project demonstrated, dozens of people were facing death for crimes they did not commit, then the entire process of capital punishment begins to seem insupportably capricious and error-prone. A major political victory came in January 2000, when Governor George Ryan of Illinois, once a staunch supporter of the death penalty, ordered a moratorium on further executions in his state pending a thorough review of capital punishment. Ryan's faith in the justice of the existing system had been shaken by a series of exonerations of Death Row inmates, some based on DNA evidence. No one should face the prospect of state-administered death, he announced, "until I can be sure with moral certainty that no innocent man or woman is facing a lethal injection."[19]

On the other hand, as we have seen, Governor Mitt Romney of Massachusetts relied on the increasing authority of DNA profiling to call for a *reinstatement* of the death penalty in his state. Science, in Romney's view, had advanced to the point where it could help to eliminate the possibility of error in sentencing the guilty, especially if, concurrently, the class of capital offenses was also severely restricted. The governor took the precaution of seeking authoritative advice. He appointed the eleven-member Massachusetts Governor's Council on Capital Punishment, who together represented "over one hundred years of collective experience,"[20] including "attorneys with prosecution, defense, and judicial experience; forensic scientists who work with prosecutors and defense attorneys; [and] persons with extensive backgrounds in law enforcement; and legal and medical academics."[21] This diverse group of experts was guided in its work by two themes the governor had repeatedly stressed: first, limitation of the death penalty to only the most heinous first degree murders (i.e., narrow application); and, second, "a strong emphasis on the use of scientific evidence to help establish the defendant's guilt, which will ensure – as much as humanly possible – that no innocent person will ever wrongly be condemned to death"[22] (i.e., near infallibility).

The Council made ten recommendations, of which seven were designed mainly to secure the quality and integrity of the legal process in capital cases, whereas the remaining three targeted issues of scientific accuracy and validity. This categorization is admittedly rough, since some issues straddle the line between, for example, recommendation five, calling for special jury instructions on the possible inaccuracy of some human evidence, such as eyewitness testimony. It is useful to distinguish the two types of recommendations, however, because they illustrate different levels of engagement with the legal and the scientific aspects of capital punishment.

The recommendations focusing on the legal process display a sophisticated understanding of systemic problems of representation and fact-finding in the law and a corresponding awareness that the actual practices of doing justice often fall short of the ideal. In particular, the Council noted that defense counseling may be inadequate and that juries may misinterpret evidence, and it suggested how trial and appellate judges might correct for these flaws. While addressing legal process issues in a spirit of informed skepticism, however, the report engaged less critically with possible systemic failings in the scientific process. The following three recommendations dealt most explicitly with science:

> (6) a requirement of scientific evidence to corroborate the defendant's guilt;
> (8) independent scientific review of the collection, analysis, and presentation of scientific evidence; and
> (10) the creation of a death-penalty review commission to review claims of substantive error and study the causes of such error.[23]

These recommendations show a basic confidence in the processes of scientific fact-finding and fact-checking, especially in after-the-fact expert review. They do not delve into biases or flaws in the conduct or interpretation of forensic science, comparable to the systemic problem of poor defense lawyering. We will return to this asymmetry in the Council's treatment of legal and scientific processes below.

The bill Romney proposed on April 28, 2005 closely followed the Council's recommendations, and was presented as virtually "foolproof" and as a "gold standard" for the nation.[24] It restricted capital punishment to a narrow subset of first-degree murders, and it raised the standard of certainty required for a capital conviction from "beyond reasonable doubt" to "no doubt." That

standard, the Council had indicated, could be met by combining corroborative evidence from several sources (e.g., DNA profiles, fingerprints, photographs) to link the defendant definitively to the murder scene. Following another Council recommendation, the Romney bill also provided for an independent scientific advisory committee whose role would be to review all physical and associative evidence in capital murder cases and make sure that it met appropriate standards of quality and reliability. In November 2005, however, the Massachusetts House of Representatives resoundingly defeated the bill, 99 to 53. A Democratic representative voiced one of the majority's key concerns: "No system that relies on scientific evidence can truly be developed that flawlessly and with no doubt separates the guilty from the innocent."[25]

Debate about the reliability of capital punishment took yet another turn in early 2006, when DNA tests of semen from Roger Coleman, a man executed by the state of Virginia in 1992, appeared to confirm that he had in fact committed the rape and murder of which he had been convicted. This was only the second time in US law enforcement history that an executed person's DNA had been tested, and much hinged on the outcome. Coleman had convinced many with his claims of innocence, and his supporters had hoped that a negative DNA match would scientifically demonstrate that a guiltless man had been put to death. As it happened, the result encouraged the proponents of capital punishment, who interpreted the episode not only as affirming Coleman's guilt, but as vindicating the administration of the death penalty as a whole. Virginia's Democratic governor, Mark R. Warner, commented, "We have sought the truth using DNA technology not available at the time the Commonwealth carried out the ultimate criminal sanction. The confirmation that Roger Coleman's DNA was present reaffirms the verdict and the sanction."[26] Peter Neufeld of the Innocence Project, however, cautioned against drawing any systemic implications about truth or falsity from a single case, arguing that "one man cannot speak for the correctness of the verdicts in a thousand other capital cases."

Developments such as these raise a number of issues for legal practitioners and students of the relationship between law and science. As the Innocence Project, Governor Romney's death penalty bill, and the Coleman case all illustrate, DNA tests today are an indispensable resource in society's efforts to secure just outcomes in legal proceedings, including crucially important decisions concerning guilt and innocence in capital cases. DNA evidence has been seized upon by parties of different political inclinations to advance diametrically opposing goals, underwriting efforts to remove some people from Death Row, condemn others to death, and build support both for and against the death penalty. For actors pursuing all these ends, trust in science is a driving force; politicians like Romney and Warner, in particular, tend to speak of DNA in the discourse of truth. Yet informed voices warn against over-estimating DNA fingerprints as foolproof, and reports of error and misconduct in both forensic and research laboratories give credence to their concerns. Why does science (in this case DNA profiling) disappoint the high expectations that it arouses, and why is its promise of delivering infallible results so often confounded in practice? Are there particular reasons to be wary of excessive reliance on genetic science, the science of DNA, for establishing truth in the criminal justice system? More generally, are there principled ways of training the legal and political imagination so that it demands from science no more and no less than science can reasonably offer – "serviceable truths"[27] that take into account science's inevitable social foundations and are good enough to advance the cause of justice, but neither promise infallibility nor hold out a mirage of it?

To shed light on these questions, it is helpful to approach the reliability of DNA evidence from a sociological angle that is often neglected in public debates about the accuracy and dependability of DNA matches. The issue, after all, is not whether DNA profiling can in theory provide unambiguous proofs of identity, but whether society is capable of generating DNA evidence that is free from bias and error. In probing this point, I begin by analyzing a presumption that seems to have gained wide currency in legal and political thinking about DNA evidence, namely, that genetic science produces truthful facts about human identity, and that establishing the truth in matters of identity is equivalent to ensuring justice. Underpinning this belief are three further propositions, each of which bears closer investigation:

- Truth-seeking in science is equivalent to truth-seeking in the law.
- Law enforcement (or forensic) science establishes the truth as reliably as science in pure research contexts.
- Genetic science is a particularly dependable source of truth, especially in disputes concerning human identity.

After examining each proposition, I return to the broader social functions of science and the law – securing truth and doing justice, respectively – and I conclude that these projects neither are nor should be seen as in all respects the same.

Truth in Science and Law

Scientific activity today is conducted under extremely diverse conditions to serve many different goals and purposes.[28] As science has moved to tackle more and more complex aspects of natural and social behavior, it is not so much the idea of truth that has shifted as society's views of what should *count* as truth in particular frameworks of inquiry. Although all forms of scientific activity strive as far as possible to find correct answers to problems, the context in which an investigation is carried out necessarily affects the kinds of conclusions it reaches. For the most part, facts produced to serve the aims of litigation do not grow out of, nor play a part in, the same kinds of social interactions as do the facts produced in basic research science or even in regulatory science.[29] Thus, the production of scientific facts needed to resolve legal conflicts differs in salient respects from the production of facts required to test a theory of consciousness, prove the safety of a drug, or assess the likely impacts of a pollutant on human health or ecosystems. Nor are findings in all these diverse domains held to the same standards of certainty or robustness. Without giving up on the truth in principle, scientists, judges, and policymakers may legitimately differ in deciding what they will accept as factual enough to support the actions expected of them. Legal decisions rely not so much on whether a particular claimed fact is true, as on its relevance to the case at hand, and on how much it contributes to the strength and quality of the totality of the evidence.

As if vindicating Pilate's skepticism, then, what counts as true for the law need not count as true for science, and in exceptional cases even scientific truths may not be accepted as valid for legal purposes. Three dimensions of difference are worthy of note, each reflecting underlying normative concerns that differentiate scientific from legal practice: first, the divergent roles of fact-finding in science and the law; second, the unequal need for certainty in scientific and legal contexts; and third, the disparate ethical constraints framing the production and use of knowledge in the two institutional settings.

First, possibly the most salient difference between legally relevant facts and normal scientific facts is that the former are frequently specific to the cases they are supposed to illuminate, whereas the latter are expected to have more general validity. Scientific fact-finding in a sense always looks forward. Its aim is to advance the frontiers of knowledge in a given field, allowing future scientists to build on today's research. Legal fact-finding, by contrast, is backward-looking. Its purpose is to recreate as closely as possible something that happened in the past, to fill in the details of a story whose broad outlines are already known or suspected. Legal facts, whether based on science or not, seldom have a life outside the class of cases for which they were produced. Their function is not to serve as facts pure and simple, but rather as *evidence.*

To be sure, facts about causation ascertained in mass exposure cases – such as tobacco, asbestos or breast implant litigation – can affect the lives of large numbers of people and carry major economic and policy consequences. Research on such problems can even shed light on previously unstudied biological or biochemical processes, such as human immune system responses to environmentally induced mutations. In general, however, it is the very specificity of facts that makes them valuable for resolving legal disputes. Though general scientific principles can help rule out some causal stories as implausible, successful legal story-telling is never complete without facts particular to the case. Seen in this light, DNA profiling has proved so important to the legal system not only because it rests on generally accepted scientific principles of genetic variability, but also, and perhaps more importantly, because it claims to provide near-unique confirmations of identity in situations where identity would otherwise remain contested.

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These differences in the function of facts means, in turn, that the social practices of fact-finding in science and law are not identical – and the differences may have important consequences for doing justice. Science generated to establish specific causation in lawsuits may never be subjected to the kind of ongoing communal scrutiny that characterizes normal research science. Unless the stakes are large, as in mass tort cases, facts developed for litigation may not be peer reviewed or published.[30] Replication, which many see as the ultimate test of truth in science,[31] is equally improbable because the questions posed to forensic science are rarely of great concern to the scientific community at large. Whether or not DNA tests conclusively showed that Nicole Simpson's blood was found in O. J. Simpson's bedroom will never arouse general scientific interest, any more than whether the glove found at the crime scene fit Simpson's hand or it was his size ten, Bruno Magli shoe that left a tell-tale footprint.[32]

For litigation-relevant science, efforts at quality control must therefore be, on the whole, front-ended – that is, they must be built into fact-finding processes in advance rather than left to be sorted out on a timeline independent of the flow of litigation. The Massachusetts capital punishment council tacitly recognized this problem when it recommended multiple layers of review to assure the quality of the scientific evidence in capital cases. The evidentiary gold standard incorporated into the Romney bill, however, struck even the Council as extremely expensive. The report noted that the costs would be tolerable because they would be incurred for only a small number of death-eligible cases.[33] Others, however, questioned whether scarce law enforcement resources should be directed toward flushing out error in a tiny handful of cases, and whether adequate resources would be allocated to upgrade crime labs to standards needed for producing high-quality evidence.

Second, cost is not the only factor that makes the law accept facts that science might still deem provisional. Delay is another important consideration, and not simply because lengthy proceedings entail costs to the system. Scientific facts needed to resolve legal disputes frequently come into being only as those disputes unfold. They are not available before the fact in some convenient storehouse of relevant, well-documented, yet case-specific facts.[34] On the principle that justice delayed is justice denied, it is unfair to expect plaintiffs to wait until all the uncertainties associated with their claims have been definitively ironed out. Legally, in any case, scientific claims are admitted into court not in consequence of their facticity *per se* – that is, not because of their likely correspondence to an external, natural truth – but because they are relevant to a story about human actions and motivations. Not surprisingly, then, the standard of certainty that litigants have to meet in order to win their case is different from the standard of certainty needed to establish the truth of a scientific fact. In civil cases, plaintiffs need only demonstrate by a preponderance of the evidence that their version of the case is more likely than not to be true. In criminal cases, the defendant needs the quantum of evidence that produces a reasonable doubt in the jury's mind in order to be acquitted. Legal evidence, in other words, need not and should not be held to scientific standards of robustness.

Third, the idea that science can be relied on to produce foolproof verdicts, as Romney's support for the death penalty strongly implied, is both ethically and practically questionable. The record of capital punishment in the United States shows that it is overwhelmingly the poor, the disadvantaged, and the racially marked who are actually executed.[35] The most important reason for this stratification in the meting out of death is that money determines the quality of legal representation. Poor defendants, it seems clear, suffer twice: first, in being socialized into conditions that are more likely to encourage violent crime; and second, in lacking the resources with which to mount a convincing defense. The application of a "no doubt" standard, such as that proposed in the Romney bill, misleadingly implies that even the most lingering doubts about guilt can be dispelled through stringent legal and scientific quality control. In practice, the degree of doubt in a juror's mind depends on an advocate's success or failure in arousing or allaying misgivings, whether about the heinousness of the crime or about the nature of the evidence, or both. Forensic science, in other words, cannot rule out doubt on its own, but only as it is represented, and contested, in court, as a component of a larger story. Well-paid lawyers defending wealthy clients tend to be more diligent in deconstructing weaknesses in the prosecution's incriminating evidence.[36] Indigent defendants, who cannot afford effective lawyering, may find their fates decided less by the strength of the scientific evidence as assessed by technical experts than by the vigor and ingenuity of the advocacy mobilized in their defense.

Finally, social policies favoring certain types of settlements may sometimes militate against an all-out reliance on science. For example, under U.S. state laws governing parentage, a child born in wedlock is presumed to be the biological offspring of both members of the married couple. While DNA tests may be used to disprove paternity, some states have imposed a two or three-year statute of limitations on such demonstrations. After that time, it becomes irrelevant whether paternity tests reveal the husband not to be the child's natural father; the stability of the family unit matters more to the state than the truth of biological parentage. Some U.S. courts have denied prisoners' requests for post-conviction DNA testing on the ground that this would violate the law's interest in finality, allowing technological progress to undermine legal settlements.[37] Important support for this position comes from a 1993 Supreme Court decision, *Herrera v. Collins*,[38] which held that a claim of actual innocence is not enough to reopen a criminal conviction based on a fair trial; the prisoner, who is no longer entitled to a presumption of innocence, must also show constitutional error. In both contexts, the law's concern for social order overrides what science deems to be the facts of the matter. The social truth of what constitutes a family and what amounts to justice in the eyes of the law operates in these cases independently of scientific truths concerning human reproduction or genetic identity. One may consider such divergences between

science and law to be arbitrary, even unjust, but it is important to recognize that they are rooted in institutional logics that are not and need not be the same. Necessarily, then, there cannot be any neat one-to-one mapping between scientific truth and legal evidence based on science.

Law Enforcement Science

Many critics of Governor Romney's death penalty bill noted that DNA evidence, like any other human activity, can never be rendered completely foolproof. Massachusetts Citizens Against the Death Penalty (MCADP), which describes itself as the oldest organization of its kind in the country, put forward just this argument in urging the bill's defeat:

> Human error can creep into the collection and analysis of any kind of scientific evidence. Examples from around the country abound. The Houston Police Department's DNA lab was shut down in December 2002 after an independent audit revealed shoddy science and an undertrained staff. Recently, Virginia's governor called for a review of that state's nationally recognized central crime lab's handling of 150 cases after it twice botched DNA tests in a capital case, in part because lab technicians felt pressured to produce quick and conclusive results despite muddled evidence.[39]

From a sociological standpoint, MCADP conflates two kinds of "error" that should be disaggregated for analytic purposes. The first is due to human beings' failure to perform technical tasks as they ought to be carried out in an ideal management system. Classically termed "human error," such mistakes are thought to be amenable to correction through better training, more internal checks, and more rigorous quality control measures. The second is due to normative pressures that are, even in theory, less easy to correct. These originate within an organizational setting that conceives its mission in particular ways, such as, in the case of law enforcement, the desire for prompt and uncontested convictions (or, as the MCADP statement says, "to produce quick and conclusive evidence").

Studies in the sociology of technological systems confirm the view that neither source of error can, in practice, be eliminated; indeed, human fallibility and organizational mission may operate in synergy and reinforce one another. Investigations in the aftermath of technological disasters provide important support for this observation. As the sociologist Diane Vaughan recounts in her study of the Challenger space shuttle disaster, it was not mere ignorance or avoidable error that caused the tragedy. NASA mangers had the information they needed in order to forestall their fateful decision to launch, namely, that the o-rings in the shuttle's booster rocket were prone to fail at the unusually low temperatures that gripped Florida on that day. They overlooked this information not through malice or evil intent, but through what Vaughan terms the "normalization of deviance" – a tendency in social organizations to treat the evidence of something being wrong as part of the nature of things, and therefore as something that can be lived with, that does not need correcting.[40]

Looking at the causes of several accidents and disasters in the United Kingdom, the sociologist of science Brian Wynne observed that operators of technological systems frequently develop a set of informal working rules that tell them, in effect, which problems are common and can be compensated for without disrupting or shutting down the entire system;[41] of course, events do not always bear out the wisdom of such choices, and some breakdowns treated as normal eventually prove to be precursors to disaster. For example, institutionalized blindness and informal working rules of the kind Wynne describes led managers at the Union Carbide plant in Bhopal, India, to overlook early warnings of the fatal 1984 gas leak that took more than 3,000 lives, injured many thousands more, and devastated a poor and densely populated city district.[42]

In the Challenger case, NASA's overriding mission to continue its highly visible manned space program contributed to an organizational culture that downplayed engineering problems such as the malfunctioning o-ring. The persistence of this organizational mindset was also held responsible for the loss of the space shuttle Columbia in February 2003, with seven crew members on board. Once again, agency managers had received, but set aside, numerous early warnings of the design defect that caused the accident: a piece of foam insulation from the fuel tank had peeled off and broken a seal on the shuttle's left wing, causing hot gases to stream in and destroy the vehicle. As the Columbia Accident Investigation Board noted, "over the course of 113 missions, foam-shedding and other debris impacts came to be regarded more as turnaround or maintenance issue, and less as a hazard to the vehicle and crew."[43]

A similar pattern of behavior, in which a powerful institutional mission leads people to underestimate the seriousness of problems, has also been identified in the context of competitive, high-visibility, biomedical research at premier academic institutions. A rash of scientific fraud and misconduct cases in the 1980s revealed that, in several cases, co-workers had suspected problems in the work of the accused scientists, but lab supervisors, seduced by the lure of success, had found

benign explanations. Thus, when Mark Spector, a brilliant young Cornell researcher, repeatedly got tricky experiments to work that had foiled other scientists, "his senior colleagues regarded him as a prodigy with 'golden hands'."[44] Eventually, a sustained investigation of his experimental data revealed that the data had been ingeniously forged. Spector's meteoric rise and downfall showed how the very promise of path-breaking areas of scientific inquiry may lead researchers, at least for a time, to hold in abeyance the "organized skepticism" through which science polices itself under ordinary circumstances.[45] A quarter-century later, the discovery that the celebrated South Korean research scientist, Dr. Hwang Woo Suk, had fabricated results in the hot area of cloning embryonic stem cells illustrated a similar dynamic of trust rather than skepticism, and a similar willingness to believe in the veracity of breakthrough results.[46] Significantly, normal peer review proved powerless in most of these cases to detect the fraud before publication.

Law enforcement agencies, as MCADP recognized in connection with the death penalty, may be especially prone to the kind of mission creep that leads to flaws in the production of evidence. An instructive case was that of David Harding, the New York State detective in charge of investigating the brutal murder of a family of four in upstate New York in 1989. The murders were committed by Michael Kinge, an ex-convict from New York City, who together with his mother, Shirley Kinge, went on a shopping spree using credit cards stolen from the victims' house. When Kinge was killed in a police shoot-out, his mother was charged and convicted as an accessory after the fact, based largely on fingerprint evidence collected by Harding and later shown to be fabricated. She served more than two years in prison before Harding's misconduct came to light and she was set free. Subsequent inquiries disclosed that Harding and some of his fellow state troopers had faked evidence in more than thirty cases.[47] It was not hard to do this; in most cases, all that the investigating officers had to do was report that objects bearing incriminating prints had been recovered from the crime scene rather than from somewhere else. Nor were such cases limited to New York. ABC News reported in February 1994 that, in the preceding five years, police had faked fingerprints in Alabama, Arizona, California, Georgia, Oklahoma, and Tennessee, in addition to New York.[48]

Questioned by James Walker, an ABC reporter, about his motivations, Harding cited both institutional pressures and the alleged infallibility of fingerprints:

> James Walker: [interviewing] Why did you select fingerprints to fake and not some other type of evidence?
>
> David Harding: In forensic investigation, fingerprint evidence is some of the best evidence you can have as far as convicting someone.
>
> James Walker: [voice-over] Harding's partner and his supervisor are in prison. Three other troopers are awaiting trial. Together prosecutors say they faked fingerprints in forty cases involving murder, burglary, rape and drugs. Why would they do it?
>
> David Harding: You get into the field and you're faced with so much violent crime, so many bodies, and the pressure to solve those crimes is intense.[49]

One sees in Harding's replies how *is* and *ought* became conflated in the thought, and eventually the actions, of a mission-driven law enforcement agent. Violent crimes ought to be solved, and fingerprints are the best evidence with which to ensure convictions. Therefore it was excusable to make sure that fingerprints turned up where they could effectively advance the cause of justice, as Harding and others came to see it. In effect, the investigator – the person with the most intimate knowledge of crime's grisly aftermath – reconstituted himself as prosecutor, jury, and judge. The enrollment of a truth-telling technology, in this case fingerprints allegedly lifted from the crime scene, proved too tempting. Morally persuaded that convincing evidence of guilt *should* have been present, Harding and his fellow detectives engineered the evidence to make sure that it *was*, in fact, so "found."

Interestingly, Harding himself was eventually found out through his own admissions rather than through third-party investigations. Ambitious for advancement, he had applied to the C.I.A. in 1991 for a job in covert operations. To impress his interviewers, and to convince them that he could be a "bad guy" when needed, Harding boasted of having faked evidence in several criminal cases back home.[50] Only when the C.I.A. reported the results of that interview back to New York State many months later was an official inquiry launched. That process, in turn, revealed that Harding's conduct was part of a more systematic pattern of misconduct in the state police force.

In the highly regimented and regulated environment of police work, one may reasonably wonder why such widespread abuses of authority were not uncovered sooner. The answer, as in cases of scientific fraud and technological disasters, again has to do with the tendency within organizations to normalize the abnormal. David Harding, it emerged, had risen through the police ranks with a reputation for ambition, hard work, intelligence, and high performance. He displayed an extraordinary knack for obtaining incriminating physi-

cal evidence, including normally hard-to-get fingerprints, but for a long time his record evoked admiration rather than suspicion from fellow officers. "'Most of us thought this guy was either incredibly good or incredibly lucky,' said a state police officer, speaking on condition of anonymity. 'But no one ever guessed he was faking it because he seemed like such a hard-working straight arrow.'"[51] This desire to believe in the probity of an attractive and exceptionally productive colleague is strikingly reminiscent of the early charitable judgments rendered by research supervisors in the science fraud cases of the 1980s.

Examples such as Harding's call into question the easy symmetry that Governor Romney embraced when he said, "Just as science can free the innocent, it can also identify the guilty." The superficial parallel between using DNA evidence to establish guilt and using it to establish innocence ignores important contextual differences. When the purpose is to free a presumably innocent, wrongfully convicted prisoner, forensic scientists have every incentive to produce the most reliable and persuasive results within their power. By contrast, when the purpose is to convict the guilty, extraordinary pressures may exist to produce results that will satisfy the prosecutor's and the public's desire for speedy convictions.

Organizational mission creep in law enforcement contexts may lead to ethical problems even when it does not produce technically faulty results. An important issue in this context is the use of partial profile or low stringency DNA database searches, in which investigators use a rare genetic trait within a family to locate an individual whose DNA precisely matches a crime scene sample. Participants in a September 2004 workshop on DNA and civil liberties, organized by the American Society of Law, Medicine & Ethics (ASLME), expressed serious reservations about this procedure. Tacitly expanding the category of "suspect" to include all those connected to the crime simply through a genetic trait; amplifying ethnic and racial biases already built into DNA databases; intrusive questioning of family members; revealing previously hidden, intimate histories of intra-familial sexual relations; and over-investing in DNA testing as compared with other aspects of law enforcement. Despite all these concerns, the lure of DNA identification is likely to push law enforcement practices toward expanded database searches in the absence of specific legal and procedural safeguards. The ASLME workshop concluded that such expansion should not occur without wider public debate.[52]

Genetic Science and Truth

The discourse of truth that has come to be associated with genetic science produces a third set of disturbances from the standpoint of the law. Before DNA profiling became available, a similar discourse of infallibility was associated with traditional fingerprinting. As we have seen, the knowledge that fingerprints are accepted as virtually foolproof markers of identity led police officers in New York and other states to fabricate this sort of evidence in dozens of cases. Simon Cole calls attention to another danger in the talk of infallibility, a logical over-extension that he terms the "fingerprint examiner's fallacy." This is the propensity to treat the following question as empirically sufficient for conviction: "Are all human friction ridge arrangements [in fingerprints] unique?" In reality, Cole argues, the law's concern is not principally with a marker's uniqueness, but with possible misattribution. To guard against false identification, the uniqueness of an individual's ridge patterns is necessary but not sufficient. The more basic question, which requires independent resolution, is the following: "How accurate are latent print examiners' attributions of source?"[53] Yet the fallacy persists that uniqueness in itself is a sufficient guarantor of reliable attributions. The tendency to assimilate the attribution question to the uniqueness question indicates how faith in science's truth-telling capability can distort both the logic and the normative function of legal inquiry.

The risk of reading scientific information beyond what it can establish with reasonable certainty is perhaps especially pronounced in the case of genetic science, which carries with it heightened connotations of precision and infallibility.

The risk of reading scientific information beyond what it can establish with reasonable certainty is perhaps especially pronounced in the case of genetic science, which carries with it heightened connotations of precision and infallibility.[54] Genes are considered to be good predictors of many facets of human identity – not only physical traits such as eye color, mental conditions such as intelligence or schizophrenia, and diseases such as inherited breast cancer, but increasingly also a series of behavioral characteristics, ranging from thrill-seeking[55] to aggression.[56] The federally funded Human Genome Project was fueled in part by the desire to locate the causes of complex human behavior at least partly in the genes, and the hope that this sort of

quasi-deterministic causal explanation would provide a rational basis for federal policies.

Daniel Koshland, former editor of *Science,* suggested in a 1989 editorial that better diagnosis of genetic illnesses would not only benefit science but would also lead to cures for persistent social problems:

> The costs of mental illness, the difficult civil liberties problems they cause, the pain to the individual, all cry out for an early solution that involves prevention, not caretaking. To continue the current warehousing or neglect of these people, many of whom are in the ranks of the homeless, is the equivalent of providing iron lungs to polio victims at the expense of working on a vaccine.[57]

Implicitly, and despite many warnings against genetic reductionism by scientists[58] and social scientists,[59] Koshland's analogy between polio and homelessness held out the promise – or, some might say, the illusion – that the latter, like the former, would some day be amenable to simple, genetically based, preventive treatments, much like vaccines.

Yet the urge to find genetic causes for behavior has often had to be reined in by later findings that reinforce the need for caution. In the early 1990s, for instance, there was a brief flurry of activity suggesting that homosexuality could be linked to biological factors.[60] Dean Hamer, a researcher at the National Institutes of Health (NIH), caused a substantial stir by announcing that his group had found an association between markers on the X chromosome and male sexual orientation, a discovery that was characterized in the same issue of *Science* as the identification of a gene influencing the development of homosexual behavior.[61] Occurring during a high point in the AIDS crisis, these scientific assertions seemed to absolve gay men (and, more tentatively, also lesbian women[62]) of responsibility for their sexual orientation. More generally, if homosexuality could be shown to rest on biological, let alone genetic, foundations, the consequences for many areas of social policy, including more recent debates about gay marriage, could be profound. Later research, however, has tended to call those earlier findings into question,[63] removing the biological supports that many might have liked to find for progressive policies toward homosexuality in American culture. Needless to say, the lack of a biological explanation for sexual orientation in no way detracts from the validity of social, legal, and ethical arguments in favor of equal treatment of all humans. If anything, the fragility of genetically determinist accounts of human sexuality only underscores the need to develop the philosophical discourse of equality, without looking toward science for ultimate justification.

Attempts to link violent behavior to genes have proved to be similarly premature and have aroused controversy. Particularly instructive was an effort spearheaded by the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA) in the early 1990s to adopt a so-called public health approach to violence in the inner cities.[64] The Violence Initiative, a $400 million program using, among others, the tools of behavioral genetics, was put forward as the Federal government's highest health research priority for the 1994 fiscal year. Frederick Goodwin, ADAMHA's head in 1992, publicly analogized American inner cities to jungles and suggested that the causes of human violence there were similar to those of violence among hyper-aggressive primates in nature.[65] Critics subsequently noted that Goodwin's biological model was shot through and through with insupportable assumptions about animal as well as human behavior. The "science" underlying the Violence Initiative looks no more secure on closer examination than was the eugenic science that undergirded racially discriminatory policies at the turn of the twentieth century and provided a rationale for the Nazi Holocaust. Nevertheless, proponents of the nature side of the nature versus nurture argument, such as Koshland and Goodwin, have continued to hold out the hope of biological solutions to deep social problems, and their dreams continue to attract research dollars from governments dissatisfied with the high cost and slow progress of social policies aimed at alleviating structural poverty and inequality.

Possibly the most surprising setback to ideas of genetic reductionism, however, came from the Human Genome Project itself, the scientific activity whose compelling justification had been that mapping and sequencing the human genome would help reveal the genetic foundations of many aspects of human biology and nature. When the completed map of the human genome was unveiled in February 2001, following a hotly contested and widely watched race between publicly and privately funded science, researchers confessed that they were most surprised at the modest number of genes contained in the full genome. At around 30,000-35,000 genes, this number was substantially lower than the 100,000 or so figure estimated by the Nobel laureate biologist and biotechnology pioneer, Walter Gilbert, in the mid-1980s.[66] Humans, it emerged, could boast not much more than twice as many genes as a fruit fly or a nematode. The complexity of the human organism had to be traced to other factors, with the clues lying more in developmental biology than strictly speaking in the genes.

Conclusion

Science in the twenty-first century serves the law in indispensable ways, by providing evidence for and against particular accounts of how things happened that are of concern to the law. Genetic science, particularly through the powerful technique of DNA-based identification, has come to play an increasingly crucial role in the conduct of legal investigations and in the resolution of myriad civil and criminal disputes. In little more than twenty-five years, DNA profiling has moved from the status of novel and contested scientific evidence to a taken-for-granted implement in the toolkit of forensic science. Police departments throughout the United States could no more do without this technology than investigators of an earlier era could have done without the technique of fingerprint identification. Much progress has been made toward standardizing the process of DNA profiling and ensuring high levels of quality control in DNA testing facilities. Yet although the admissibility of DNA evidence is no longer in doubt, its use in the legal system continues to raise new questions about civil liberties and, more broadly, about the law's reliance on science to establish the truth.

The association of DNA with truth, and its near cousin infallibility, has laid the basis for a series of tacit assumptions that need to be made explicit and challenged, as this article has sought to do. Neither the expectation that DNA tests deliver infallible identifications nor the corollary that the law should unhesitatingly accept the truths offered by genetic science hold up under critical examination. The arguments are both empirical and ethical. In practice, the production of DNA evidence is vulnerable to human error and, especially in the context of law enforcement, also to organizational pressures that are likely to enhance the risk of false identifications. Ethically, there are good reasons why law enforcement agencies should shy away from excessive reliance on DNA, as for example in conducting low stringency database searches on familial DNA. There are times, too, when scientific evidence may be considered good enough to admit in court though it does not yet meet standards of scientific certainty. Given the functional differences between legal and scientific fact-finding, the law's criteria of relevance and reliability need not precisely mirror science's criteria for accepting the facticity of new findings or assertions.

As behavioral genetics offers new characterizations of human nature, additional temptations may come into play for law enforcement agencies eager to take preventive steps against crime and violence. Looking for genetic markers of criminality may prove to be especially appealing. But here again the historical record suggests a need for caution in the enrollment of science for legal purposes. Premature theorizing and reductionist explanations have dogged the science of heredity for more than a hundred years. Where law and social policy are concerned, the turn to genetics for foolproof answers may turn out to be a dangerous hankering after fool's gold.

Twenty centuries after Pontius Pilate's infamous abdication of judicial responsibility, we are in a position to say that he may have been right in questioning the absoluteness of truth – though not in his decision to leave judgment to the multitude. Scientific truth-making, in particular, as human beings engage in it, is always a social enterprise. It is situated in particular places and circumstances; it is context-specific, purposive, and culturally embedded. As such, even scientific claims are subject to distortion, through imperfections in the very human systems that produced them. In attempting to render justice, the law's objective should be, in part, to restore to view these potential shortcomings, instead of uncritically taking on board a decontextualized image of science that ignores its social and institutional dimensions. Doing justice, after all, demands a complex balancing of multiple considerations, in an analytic framework that keeps social contexts firmly within view while constructing compelling narratives of cause and blame. When science enters the courtroom, it should do so as an adjunct to the law's need for credible but meaningful story-telling. In a court of law, science cannot hold itself out as simply science, the source of transcendental truths; more modestly, and with appropriate caveats, it can be the source of just evidence.

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