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The Admissibility of TrueAllele: A Computerized DNA Interpretation System

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I. Introduction

In criminal cases, the stakes regarding DNA evidence run high. The admissibility of one piece of DNA evidence can alter the outcome of the case. Imagine that the prosecution charges Mr. Smith with murder. The police found what they believe is Mr. Smith's DNA on the victim at the scene of the crime. They send the sample to the Department of Forensic laboratory. Technicians at the laboratory use a certain method of DNA interpretation called "human interpretation." Based on this method, the lab reports an inconclusive result. The result may be inconclusive because the sample is too complex (contains too many contributors) or is degraded or contaminated. The result might be inconclusive because the DNA does not belong to Mr. Smith. Regardless, without conclusive DNA evidence tying Mr. Smith to the scene of the crime, the prosecution may be unable to meet its burden of proof that Mr. Smith committed the murder. Now imagine that the Department of Forensic laboratory recently implemented a new type of DNA interpretation technology. Instead of the traditional human interpretation technique, the lab uses new computerized DNA interpretation technology. Using the technology, the lab yields conclusive results. An expert for the prosecution testifies that Mr. Smith's DNA matches the sample DNA found on the victim, and a jury convicts Mr. Smith.

In criminal cases, the prosecution carries the heavy burden of proof—beyond a reasonable doubt—for each and every element of a crime.[1] In the past few decades, technological advances have

1. *See In re* Winship, 397 U.S. 358, 363–64 (1970) (discussing the vital role that the "beyond a reasonable doubt" standard plays in criminal procedure and holding that "the Due Process Clause protects the accused against conviction except upon proof beyond a reasonable doubt of every fact necessary to constitute the crime with which [the defendant] is charged").

aided the prosecution in carrying this burden. Specifically, the advent of DNA technology allows prosecutors to conclusively allege, in numerical terms, the likelihood that a particular defendant's DNA is present at a particular location. Admissibility of scientific evidence hinges on standards developed in the early 1900s.[2] These standards continuously developed over subsequent decades.[3] Like many areas of the law, the standards may struggle to keep up with evolving technology. Recently, innovative computer interpretation programs began replacing widely accepted human interpretation of DNA evidence.[4] One such computer program is TrueAllele. According to its website, TrueAllele objectively infers genetic profiles from DNA samples, and automatically matches the resulting profiles against available profiles contained in large databases.[5] In practice, TrueAllele sometimes yields conclusive results of DNA samples when human interpretation of the same sample does not.[6]

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2. *See* Frye v. United States, 293 F. 1013, 1013–14 (D.C. Cir. 1923) (discussing one standard for admission of scientific testimony).

3. *See* Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579, 592–95 (1993) (overruling *Frye* and discussing a second standard for admission of scientific evidence).

4. *See* William C. Thompson et al., *Forensic DNA Statistics: Still Controversial in Some Cases*, THE CHAMPION, Dec. 2012, at 18 [hereinafter Thompson, *Controversial Forensic DNA Statistics*], http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2214459 (discussing one computerized DNA interpretation program whose "sales pitch appears to be working").

5. *See DNA Casework*, CYBERGENETICS, http://www.cybgen.com/systems/casework.shtml (last visited Mar. 20, 2015) (describing the TrueAllele program) (on file with the Washington and Lee Law Review). Furthermore, in *Maryland v. King*, 133 S. Ct. 1958 (2013), the Supreme Court upheld the constitutionality of collecting an arrestee's DNA by taking and analyzing a cheek swab. *See id.* at 1980 ("When officers make an arrest supported by probable cause [and detain the suspect in custody], taking and analyzing a cheek swab of the arrestee's DNA is, like fingerprinting and photographing, a legitimate police booking procedure that is reasonable under the Fourth Amendment."). This decision will likely result in an expansion of DNA databases. *See id.* at 1988 (Scalia, J., dissenting) (discussing the great expansion of fingerprint databases after the Court upheld the constitutionality of fingerprinting arrestees).

6. *See* Thompson, *Controversial Forensic DNA Statistics*, *supra* note 4, at 18 ("[TrueAllele] claim[s] it can be used in all types of cases, including problematic cases in which sample limitations render the test results less than perfectly reliable. Better yet, the system often produces statistics that are even more impressively incriminating than the statistics produced by conventional [DNA interpretation] methods.").

The admissibility of the computerized results is another matter. Courts, prosecutors, and defense attorneys are ill-equipped to gauge the admissibility of these complicated technologies.[7] Consequently, both sides typically bring experts into court to educate the judge or jury about the new technology, and discuss its admissibility.[8] Experts, however, are rarely neutral parties. And disputes about the admissibility of the results often occur.[9]

When analyzing the admissibility of emerging scientific technologies, judges balance various competing principles of criminal law. These principles include accuracy and fairness.[10] While the computerized DNA technology may claim to yield accurate results (and may in fact yield accurate results), defense attorneys—and to some extent judges—must test this claim and uphold due process by admitting the evidence in a fair manner.

This Note discusses the admissibility of TrueAllele, a computerized DNA interpretation technology. The Note begins, in Part II.A, with a discussion about the admissibility of scientific evidence in general, including the history and current state of the *Frye* and *Daubert* evidentiary standards. Part II.B analyzes the historical evolution of DNA. Part III introduces basic concepts required to understand DNA evidence, including amplification and both human and computerized statistical interpretation.[11] Part IV focuses on the current state of admissibility of the TrueAllele technology. And Part V discusses the admissibility of the TrueAllele technology in connection with the norms of criminal procedure, specifically accuracy and fairness.

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7. *See* William C. Thompson & Simon Ford, *DNA Typing: Acceptance and Weight of the New Genetic Identification Tests*, 75 VA. L. REV. 45, 52–53 (1989) [hereinafter Thompson & Ford, *DNA Typing*] (discussing the challenges and complexity of DNA typing).

8. *See id.* at 12 (noting that experts "sometimes disagree about the interpretation and statistical characterization of [DNA] test results").

9. *See id.* at 20 (describing one case where a dispute arose about whether the TrueAllele expert had "cherry-picked" his data to reach a more incriminating result).

10. *See* JOSHUA DRESSLER & GEORGE C. THOMAS III, CRIMINAL PROCEDURE: PRINCIPLES, POLICIES AND PERSPECTIVES 36–38 (5th ed. 2013) [hereinafter DRESSLER & THOMAS, CRIMINAL PROCEDURE] (discussing accuracy and fairness as two norms of the criminal process).

11. A full discussion of the differences between human and computerized interpretation of biostatistics is beyond the scope of this Note.

II. The Admissibility of Scientific Evidence

Traditionally, the admissibility of scientific evidence revolved around its reliability[12]—the more reliable the scientific evidence, the more likely the scientific community or a judge will accept and admit the evidence.[13] But what is reliability? Reliability of scientific evidence is defined in many ways. For example, reliability may focus on the accuracy of the result,[14] the accuracy of the process that led to the result,[15] or what members of the relevant scientific community think about that process and result.[16] All of these factors are important, and typically courts do not focus on just one.[17]

Historically, courts have changed the definition of reliability, which in turn alters the admissibility standard of scientific evidence.[18] This shift is traditionally attributed to a change in the

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12. In addition, admissibility of scientific evidence, like all evidence, revolves around its relevance. GEORGE FISHER, EVIDENCE 22 (Robert C. Clarke et al. eds., 3d ed. 2013) (discussing the general principles of evidentiary relevance applicable to all admissible evidence). For the purposes of this Note, relevance is assumed *arguendo* because in almost all cases involving TrueAllele, the piece of evidence the prosecution seeks to admit against the defendant is relevant to the case.

13. *See* Frye v. United States, 293 F. 1013, 1013–14 (D.C. Cir. 1923) (discussing one standard for admission of scientific testimony); Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579, 592–95 (1993) (same).

14. *See Daubert*, 509 U.S. at 594 (discussing the "known or potential error rate" as a factor important to a determination of reliability of scientific evidence).

15. *See id.* at 593–94 (discussing whether a technique "can be (and has been) tested" and "the existence and maintenance of standards controlling the technique's operation" as factors important to a determination of reliability of scientific evidence).

16. *See id.* (discussing whether a technique "can be (and has been) tested" and whether a technique has been "subjected to peer review and publication" and the "general acceptance" of the technique in the relevant scientific community as factors important to a determination of reliability of scientific evidence); *Frye*, 293 F. at 1014 (discussing whether a technique has "gained general acceptance in the particular field" as a factor important to a determination of reliability of scientific evidence).

17. *See generally Daubert*, 509 U.S. 579 (using a five-factor test to determine admissibility of scientific evidence).

18. *See* Gen. Elec. Co. v. Joiner, 522 U.S. 136, 142 (1997) (discussing the shift in admissibility standards and comparing *Daubert* and *Frye*, stating that "the Federal Rules of Evidence [and therefore, presumably *Daubert*] allow district courts to admit a somewhat broader range of scientific testimony than

"gatekeeper"[19] of scientific evidence. The gatekeeper is the person who stands between scientific evidence and its admissibility.[20] In early cases, and in a minority of states today,[21] the scientific community serves as the gatekeeper.[22] In later cases and in a majority of states today,[23] the judge serves as the gatekeeper.[24] The different definitions of reliability and the different gatekeepers affect the admissibility analysis of the scientific evidence.[25]

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would have been admissible under *Frye*").

19. *See Daubert*, 509 U.S. at 597 (introducing the terminology of the "gatekeeping role" of the judge).

20. *See* Edward K. Cheng & Albert H. Yoon, *Does* Frye *or* Daubert *Matter?: A Study of Scientific Admissibility Standards*, 91 VA. L. REV. 471, 477 (2005) (discussing *Daubert*'s "gatekeeping role" as the "most important[]" change and later concluding this change resulted in a new "[d]octrine [that] provides the framework by which judges analyze facts and decide cases, so changing that framework should presumably change outcomes"). Cheng and Yoon later suggest that "a state's adoption of *Frye* or *Daubert* makes no difference in practice." *Id.* at 503.

21. *See* Michael H. Graham, *Reliability "Gatekeeping" under* Daubert/Kumho/*Rule 702: Historical Development and Assessment*, 5 HANDBOOK OF FED. EVID. § 702:5 (7th ed. 2013) ("Eleven states have specifically rejected *Daubert* . . . in favor of retaining the standards enunciated in *Frye v. United States*." (internal citations omitted)).

22. *See, e.g.*, Frye v. United States, 293 F. 1013, 1014 (D.C. Cir. 1923) (recognizing that the evidence must have "gained general acceptance" in the particular scientific community in order to be admissible).

23. *See* Graham, *supra* note 21, § 702:5

> Since the U.S. Supreme Court's 1993 decision in *Daubert*, the standards set forth in that opinion have become the majority rule in the United States in analyzing expert opinion testimony. Currently, 27 states have held that the *Daubert* standards are either helpful or controlling in their determinations regarding the admissibility of expert opinion evidence (citations omitted).

24. *See, e.g.*, Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579, 597 (1993) (attributing the role of "gatekeeper" to the federal judge).

25. *See generally* Cheng & Yoon, *supra* note 20, at 503 (describing the different theories about whether a state's adoption of *Frye* or *Daubert* makes any difference in practice).

A. Scientific Admissibility Doctrines

1. The Frye *Standard: General Acceptance*

In 1923, Mr. Frye was on trial for second-degree murder.[26] During the trial, the defense offered the testimony of a scientist who had conducted a "systolic blood pressure deception test"—an early version of a polygraph test[27]—to prove Mr. Frye was not hiding facts or his guilt.[28] The theory supporting the deception test was that the "truth is spontaneous and comes without conscious effort, while the utterance of a falsehood requires a conscious effort, which is reflected in the blood pressure."[29] The defense offered the scientist as an expert to testify about the results obtained.[30] The prosecution objected to the admissibility of the deception test, and the trial court sustained the objection and did not allow the expert to testify.[31] On appeal, the United States Court of Appeals for the District of Columbia affirmed the trial court's decision[32] using the following standard:

> Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, *the thing from which the deduction is made must be sufficiently established to*

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26. *Frye*, 293 F. at 1013.

27. *See* Paul C. Giannelli, *The Admissibility of Novel Scientific Evidence:* Frye v. United States*, A Half-Century Later*, 80 COLUM. L. REV. 1197, 1204 n.41 (1980) ("The machine used in *Frye* was a forerunner of the modern polygraph and is more accurately described as a monograph, since, unlike the modern polygraph, it measured only one physiological response—blood pressure.").

28. *Frye*, 293 F. at 1013–14.

29. *Id.* at 1014.

30. *See id.* ("Prior to the trial defendant was subjected to this deception test, and counsel offered the scientist who conducted the test as an expert to testify to the results obtained.").

31. *See id.* ("[C]ounsel offered the scientist who conducted the test as an expert. . . . The [government objected], and the court sustained the objection. Counsel for defendant then offered to have the proffered witness conduct a test in the presence of the jury. This also was denied.").

32. *See id.* (affirming the trial court's decision to exclude the evidence).

> *have gained acceptance in the particular field in which it belongs.*[33]

The appellate court denied the expert testimony because "the systolic blood pressure deception test [had] not yet gained such standing and scientific recognition among physiological and psychological authorities as would justify the courts in admitting expert testimony deduced from the discovery, development, and experiments thus far made."[34]

Put simply, the *Frye* standard requires that the relevant scientific community accept the scientific technique in question.[35] This acceptance launches the technique from the "experimental" stage to the "demonstrable" stage, and therefore allows for judicial recognition.[36] Under the *Frye* standard, the relevant scientific community as a whole must accept the technique. One expert's opinion, or even several experts' opinions, may be insufficient to show that a particular technique has entered the demonstrable stage.[37] The *Frye* standard, therefore, places the "gatekeeping" power with the scientific community.

2. The Daubert *Standard: A Five-Factor Balancing Test*

For decades courts analyzed scientific techniques under the *Frye* doctrine.[38] In 1993, the Supreme Court of the United States decided *Daubert v. Merrell Dow Pharmaceuticals, Inc.*[39] In

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33. *Id.* (emphasis added).

34. *Id.*

35. *See* Giannelli, *supra* note 27, at 1205 ("*Frye* imposes a special burden—the technique must be *generally accepted by the relevant scientific community*.").

36. *See id.* ("A novel technique must pass through an 'experimental' stage in which it is scrutinized by the scientific community. Only after the technique has been tested successfully in this stage and has passed into the 'demonstrable' stage will it receive judicial recognition.").

37. *See id.* ("In contrast to the relevancy approach, it is not enough that a qualified expert, or even several experts, believes that a particular technique has entered the demonstrable stage . . . .").

38. *See* Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579, 585 (1993) ("In the last 70 years since its formation in the *Frye* case, the 'general acceptance' test has been the dominant standard for determining the admissibility of novel scientific evidence at trial." (citing ERIC GREEN & CHARLES NESSON, PROBLEMS, CASES AND MATERIALS ON EVIDENCE 649 (1983))).

39. 509 U.S. 579 (1993).

Daubert, the petitioners were children born with serious birth defects allegedly caused by their mothers' ingestion of Bendectin, a prescription anti-nausea drug marketed by Merrell Dow Pharmaceuticals, Inc.[40] Both sides presented well-credentialed experts to testify about Bendectin's risk factor for human birth defects.[41] Merrell Dow submitted an affidavit from Dr. Steven H. Lamm, a physician and epidemiologist, stating that he had reviewed more than 30 published studies involving over 130,000 patients, and no study had found Bendectin to be a substance capable of causing birth defects.[42] The petitioners moved to admit eight experts of their own who concluded that Bendectin could cause birth defects.[43] The petitioner's experts' conclusions were based in part on the "'reanalysis' of previously published epidemiological (human statistical) studies."[44] Following the *Frye* standard, the trial court denied admission of the petitioners' eight experts.[45] The court based its inadmissibility analysis on the fact the relevant scientific community did not "generally accept[]" the scientific techniques used by the petitioner's experts.[46] On appeal, the Ninth Circuit rejected the reanalysis of published studies because the experts generated this reanalysis solely for litigation, and the reanalysis had not undergone peer-review.[47]

On appeal in the United States Supreme Court, the petitioners argued that the Federal Rules of Evidence superseded

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40. *Id.* at 582.

41. *See id.* at 582–83 (characterizing the respondent's expert as "well-credentialed" and characterizing the petitioner's expert as possessing "impressive credentials").

42. *Id.* at 582.

43. *Id.* at 583.

44. *Id.*

45. *See id.* at 583–84 (discussing how the trial court concluded that the petitioners' evidence did not meet admissibility standards).

46. *See id.* at 584 ("The court declared that expert opinion based on a methodology that diverges significantly from the procedures accepted by recognized authorities in the field . . . cannot be shown to be 'generally accepted as a reliable technique.'").

47. *See id.* ("Contending that reanalysis is generally accepted by the scientific community only when it is subjected to verification and scrutiny by others in the field, the [Ninth Circuit] rejected petitioners' reanalyses as 'unpublished, not subjected to the normal peer review process and generated solely for use in litigation.'").

the *Frye* test,[48] specifically Rule 702,[49] which at the time provided that, "[i]f scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education may testify thereto in the form of an opinion or otherwise."[50] The Supreme Court dismissed the *Frye* test as "rigid" and "at odds with the 'liberal thrust' of the Federal Rules and their 'general approach of relaxing the traditional barriers to 'opinion' testimony.'"[51] After overruling *Frye*, the Court set forth a new test to place limits on the admissibility of scientific evidence in which the "trial judge must ensure that any and all scientific testimony or evidence admitted is not only relevant, but reliable."[52]

In *Daubert*, the Court offered five "general observations" to guide trial judges in their assessment of the reliability of a scientific theory or technique. These "general observations" are now known as the five *Daubert* factors. The *Daubert* factors include: (1) whether the technique "can be (and has been) tested;"[53] (2) whether a technique has been "subjected to peer review and publication;"[54] (3) "the known or potential rate of error;"[55] (4) "the existence and maintenance of standards controlling the technique's operation;"[56] and (5) "general acceptance" in the relevant scientific community.[57] The factors do not represent "a definitive checklist or test."[58] In fact, the majority stated that the inquiry into admissibility of scientific

48. *See id.* at 587 ("Petitioners' primary attack, however, is not on the content but on the continuing authority of the rule. They contend that the *Frye* test was superseded by the adoption of the Federal Rules of Evidence.").

49. FED. R. EVID. 702. Rule 702 was amended in 2000 and restyled in 2011. *See* FISHER, *supra* note 12, at 796 (discussing the changes to Rule 702). The Rule today contains more detail than in 1993. *Id.*

50. Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579, 588 (1993).

51. *Id.* (citation omitted).

52. *Id.* at 589.

53. *Id.* at 593.

54. *Id.*

55. *Id.* at 594.

56. *Id.*

57. *Id.*

58. *Id.* at 593.

evidence is "a flexible one."[59] The *Daubert* standard squarely shifted the gatekeeping power from the scientific community to the judge.[60]

Ultimately, the Court remanded *Daubert* because the lower court focused too much on the 'general acceptance in the scientific community' factor.[61] On remand, for the first time, a court acted as a gatekeeper and applied the *Daubert* five-factor test.[62] Clearly frustrated with its new role,[63] the Ninth Circuit begrudgingly took on the task of "resolv[ing] disputes among respected, well-credentialed scientists about matters squarely within their expertise, in areas where there is no scientific consensus as to what is and what is not 'good science,' and occasionally . . . reject such expert testimony because it was not 'derived by the scientific method.'"[64] After weighing most of the five *Daubert* factors,[65] the court affirmed its original decision, once again rendering the eight experts' testimonies inadmissible.[66]

*3. Post-*Daubert*'s Practical Impact and Comparing the Standards*

The Justices who decided *Daubert* most likely believed the *Daubert* test eased the standards for admission of scientific

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59. *Id.* at 594.

60. *See id.* at 597 (discussing the "gatekeeping role" of the judge).

61. *Id.* at 597–98.

62. Daubert v. Merrell Dow Pharms., Inc., 43 F.3d 1311, 1316 (9th Cir. 1995).

63. *See id.* at 1315–16 (characterizing the task of applying the *Daubert* factors as "daunting," "difficult," and "uncomfortable").

64. *Id.* at 1316.

65. *See id.* at 1317 n.4 (disregarding two of the *Daubert* factors—whether the technique employed "can be (and has been) tested" and what its "known or potential rate of error" might be—as too difficult to apply in this particular case).

66. *See id.* at 1321–22 (rendering the testimony inadmissible under the *Daubert* analysis). The court of appeals concluded that the petitioners' experts' testimony was not "helpful" under the second prong (relevance) of Rule 702. *Id.* at 1321. The experts' substantive testimony did not conclude that the Bendectin actually caused the plaintiffs' injuries. *Id.* In addition, the testimony did not comment on the statistical likelihood that Bendectin actually caused the plaintiff's injuries. *Id.* The testimony, therefore, did not meet the standard of required proof of causation (preponderance of the evidence) and was ultimately not relevant. *Id.* at 1322.

evidence.[67] In fact, just a few years later in 1997, the Supreme Court restated that the "Federal Rules of Evidence allow district courts to admit a somewhat broader range of scientific testimony than would have been admissible under *Frye*."[68] Other studies show, however, that the *Daubert* standard had little impact on the admissibility of expert testimony (at least in the civil sphere).[69] The lack of impact may be, in part, because the 'general acceptance in the scientific community' factor serves as one of the five *Daubert* factors.[70] Some judges inevitably give greater weight to this factor, and therefore, the *Frye* and *Daubert* tests may produce the same result.[71]

B. Early Admissibility of DNA Evidence

During the advent of DNA technology, courts applied the *Frye* and *Daubert* standards to DNA evidence. The initial acceptance of DNA evidence in the courts happened quickly, over the course of just a few years. As technology progresses, however, courts must constantly reevaluate the admissibility of DNA.

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67. *See* Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579, 588, 596 (1993) (classifying the new *Daubert* standard as "at odds with the 'liberal thrust' of the Federal Rules" and discussing the allowance of "shaky but admissible evidence").

68. Gen. Elec. Co. v. Joiner, 522 U.S. 136, 142 (1997).

69. *See, e.g.*, Lloyd Dixon & Brian Gill, *Changes for Admitting Expert Evidence In Federal Civil Cases Since the* Daubert *Decision*, 8 PSYCHOL. PUB. POL'Y & L. 251, 291–302 (2001) (examining *Daubert*'s effect on the proportion of challenged evidence excluded and its effect on summary judgment in civil cases); *see also* Cheng & Yoon, *supra* note 20, at 488–89 (examining the removal rates between jurisdictions employing different standards); Eric Helland & Jonathan Klick, *Does Anyone Get Stopped at the Gate? An Empirical Assessment of the* Daubert *Trilogy in the States*, 20 SUP. CT. ECON. REV. 1, 18–31 (2012) (examining state-to-state variance by measuring litigants' likelihood of offering different types of expert witnesses).

70. *See supra* note 57 and accompanying text (listing "general acceptance" as one of the five *Daubert* factors).

71. *See* Dixon & Gill, *supra* note 69, at 299–300 (discussing studies that indicated that, in post-*Daubert* cases, general acceptance was no longer sufficient by itself for admission of evidence but a lack of general acceptance remained an important barrier to admission).

1. Early Controversies About the Admissibility of DNA Evidence

After its introduction to the criminal forensics scene in 1987, DNA evidence quickly gained popularity in the United States.[72] Initially, members of the legal and law enforcement communities used the novel evidence conservatively;[73] however, DNA evidence quickly gained traction once courts started admitting the new technology.[74] Companies marketed DNA evidence to the public and prosecutors as impenetrable scientific evidence that would result in obtaining accurate convictions.[75] Defense attorneys

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72. *See* Janet C. Hoeffel, Note, *The Dark Side of DNA Profiling: Unreliable Scientific Evidence Meets the Criminal Defendant*, 42 STAN. L. REV. 465, 476–77 (1990) (discussing the early popularity of DNA evidence in the United States).

73. *See id.* at 477 n.56 ("In September 1987, only one-third of the nation's crime lab directors thought DNA typing was ready for forensic use." (citing Mark Thompson, *DNA's Troubled Debut*, CAL. LAW., 1988, at 44)); *id.* ("Professor George Sensabaugh of the University of California at Berkeley, a researcher in the field of forensic science and DNA typing, predicted in 1987 that it would take another five years of research before the DNA typing technique would be able to pass muster in California courts." (citing Isadora W. Lomhoff, *By Their DNA, So Shall Ye Know Them*, CAL. LAW., 1987, at 9)).

74. *See id.*

> In early 1988, consistent with such conservatism, California Attorney General John Van de Kamp held the firm position that DNA evidence was not ready for the courtroom. He explained, "We have every opportunity to botch this historic moment. How might we do that? By getting mesmerized with DNA's potential and slipping into a counterproductive scramble to rush the technology from laboratory to courtroom in record time."

(citing Mark Thompson, *DNA's Troubled Debut*, CAL. LAW., 1988, at 40, 42); *cf. id.*

> However, only one year later, seeing that other jurisdictions were not hesitating to admit the evidence, Van de Kamp suddenly announced full-fledged endorsement of the procedure, preparing legislation to establish five regional DNA testing labs and to provide for a databank of DNA profiles of convicted sex criminals, thereby moving California from last to near first in the great race to admit this new crime-fighting technology.

(citing William Vogeler, *Van de Kamp to Push for DNA Testing*, DAILY J., Jan. 25, 1989, at 1 col. 2).

75. *See id.* at 477 n.58 (describing DNA propaganda from the late 1980s that claimed the technology was so "precise" that "[i]f you're a criminal, it's like leaving your name, address, and social security number at the scene of the crime" and "[t]o see justice served, ifs, buts, or maybes aren't enough. Get the

struggled to deal with the new evidence due to its complex scientific nature.[76]

In 1989, however, members of the scientific community went on record as not necessarily having reached a general consensus about the admissibility of DNA evidence. In *People v. Castro*,[77] the Superior Court of Bronx County, New York, conducted a twelve-week "exhaustive evaluation of both the DNA procedure and the application of traditional admissibility rules."[78] *Castro* involved the murder of a twenty-year-old pregnant woman and her two-year-old daughter in Bronx, New York.[79] The police had few leads until they arrested Joseph Castro and found dried blood on his watch.[80] Prosecutors sent the sample from the watch, the victim's blood, and the suspect's blood to a private laboratory named Lifecodes. Lifecodes reported a match between the blood on the watch and the victim's blood.[81] The prosecution sought to introduce the DNA results as evidence.[82] Mr. Castro sought to exclude the DNA typing evidence.[83] Defense experts uncovered serious errors in Lifecodes's tests.[84] In fact, the prosecution's

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definitive answer [with DNA]").

76. *See id.* at 477 n.59 (quoting one defense attorney as stating "there has been little, if any, informed cross examination of private DNA vendors and few qualified expert witnesses testifying in opposition. The defense lawyers in these cases, often court appointed counsel, have been overwhelmed").

77. 545 N.Y.S.2d 985 (Sup. Ct. 1989), *abrogated by* People v. Wesley, 589 N.Y.S.2d 197 (N.Y. App. Div. 1992).

78. Stephen M. Patton, *DNA Fingerprinting: The* Castro *Case*, 3 HARV. J. L. & TECH. 223, 223 (1990).

79. *See Castro*, 545 N.Y.S.2d at 985 ("The defendant stands accused of two counts of murder in the second degree, it being alleged that on February 5, 1987 he stabbed to death twenty-year-old Vilma Ponce, who was seven months pregnant at the time, and her two-year-old daughter.").

80. *See id.* ("A wrist watch worn by the defendant at the time of his arrest was seized. What appeared to be bloodstains on the watch were noted by the detectives. The defendant stated that the blood was his own.").

81. *See id.* at 998 ("Lifecodes declares a match by visual observation in a blind reading of the autoradiograph.").

82. *See id.* at 985–86 ("The People, intending to prove at trial that the origin of the bloodstains on defendant's wristwatch was the blood of the adult victim, and not the blood of the defendant, seek to introduce evidence of DNA identification tests.").

83. *See id.* at 988 (listing the expert witnesses testifying for the defense).

84. *See id.* at 996 ("In a piercing attack upon each molecule of evidence presented, the defense was successful in demonstrating to this court that the

main expert witness recanted his testimony, and the defense and prosecution experts issued a joint statement that "[t]he DNA data in this case are not scientifically reliable enough to support the assertion that the samples . . . do or do not match. If these data were submitted to a peer-reviewed journal in support of a conclusion, they would not be accepted. Further experimentation would be required."[85] Before ruling this particular DNA evidence inadmissible, the court made a general finding that under the *Frye* admissibility standard, "DNA forensic identification tests" are generally acceptable for both inculpatory and exculpatory purposes.[86] The court, however, rendered this particular evidence inadmissible because the testing laboratory had not followed "scientifically accepted tests."[87]

The court reached its finding after recognizing the difficulty of applying the *Frye* test to such complex scientific evidence. In an attempt to refine *Frye* to accommodate complicated DNA evidence, the court issued a three-part test for the admissibility of DNA:

> *Prong I.* Is there a theory, which is generally accepted in the scientific community, which supports the conclusion that DNA forensic testing can produce reliable results?
>
> *Prong II.* Are there techniques or experiments that currently exist that are capable of producing reliable results in DNA identification and which are generally accepted in the scientific community?

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testing laboratory failed in its responsibility to perform the accepted scientific techniques and experiments in several major respects."); Patton, *supra* note 78, at 229–30 (discussing the unreliable tests performed by Lifecodes). Many issues that arise with DNA fingerprinting stem from a low quality sample. *See id.* at 229 n.27 (discussing difficulties that arise with DNA fingerprinting due to the lack of control over the sample).

85. *See* Hoeffel, *supra* note 72, at 478.

86. *See* People v. Castro, 545 N.Y.S.2d 985, 995 (Sup. Ct. 1989) ("This court concludes that the credible scientific evidence in this case supports the conclusion that DNA forensic identification evidence meets the *Frye* standard. . . . Therefore, it is the conclusion of this court that DNA forensic identification tests to determine inclusions are reliable and meet the *Frye* standard of admissibility.").

87. *See id.* at 997–98 ("Accordingly, the credible testimony having clearly established that the testing laboratory failed to conduct the necessary and scientifically accepted tests, the evidence demonstrating an inclusion is inadmissible as a matter of law.").

> *Prong III.* Did the testing laboratory perform the accepted scientific techniques in analyzing the forensic samples in this particular case?[88]

In Prong I, the court reviewed the theory of DNA analysis in general and explained that the scientific community is in agreement that "DNA forensic testing can produce reliable results."[89] In Prong II, the court reviewed the current DNA "techniques and experiments" to assess whether those techniques are "capable of producing reliable results in DNA identification and which are generally accepted in the scientific community."[90] The court noted that all of the procedures used had "gained general scientific acceptance;" however, the "transfer of this [generally accepted] technology to DNA forensic identification . . . generated much . . . dispute."[91] In other words, the court did not focus solely on the historically accepted techniques and instead conducted a thorough admissibility analysis because of the new nature of the technology. The court ultimately relied on the "credible scientific evidence" surrounding these techniques and experiments and concluded "that DNA forensic identification evidence meets the *Frye* standard."[92] Pursuant to *Frye*, the court deferred to the scientists who the

88. *Id.* at 987.

89. *Id.* at 988.

90. *Id.* at 989. The techniques specifically in question were the restriction fragment length polymorphism method of DNA typing. These techniques, as the court defined them, included:

(1) digestion of DNA into fragments by restriction enzymes creating RFLPs; (2) separation of the DNA fragments by electrophoresis; (3) staining the separate fragments with ethidium bromide so that they can be illuminated by ultraviolet exposure; (4) denaturing, or separating the two DNA strands, and fixing them to a nylon membrane; (5) hybridization of the single strand of DNA by marking it at a specific location with a radioactive probe; and (6) reproducing a picture of the radioactively marked DNA onto an x-ray film—or autoradiograph or autorad; (7) Interpretation of Autorads; and (8) Population Genetics, if necessary.

Id. at 989–93. In addition, the court took up "additional experiments, techniques, and controls" including (1) mixing experiment; (2) serial dilution; (3) non-polymorphic probe; (4) synthetic probes; (5) male and female DNA in control lane when examining sex chromosomes; and (6) the matching rule. *See id.* at 993–95 (discussing each of these additional experiments in turn).

91. *Id.* at 990.

92. *Id.* at 995.

court recognized "will be in a position to generate reliable results."[93]

Finally, in Prong III, the court examined the reliability of the specific tests performed by Lifecodes. The court found that Lifecodes failed to perform specific experiments and techniques, and therefore did not follow the accepted scientific procedures.[94] Ultimately, the court accepted DNA fingerprinting as admissible scientific evidence, but excluded Lifecodes's specific DNA fingerprinting analysis of Mr. Castro.[95]

The court's thorough analysis in *Castro*, particularly the analysis in Prong III, played a significant role in shaping how courts applied the *Frye* standard to DNA evidence.[96] After *Castro*, several courts more closely examined their scientific evidentiary standard with regards to DNA evidence.[97] At a minimum, *Castro* and its aftermath created a dialogue between attorneys, experts, and courts about the proper standard for the admissibility of DNA evidence.[98] Faced with a new and complicated technology,

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93. *Id.*

94. *See id.* at 996–98 (describing the specific procedures that Lifecodes failed to complete).

95. *See id.* at 995, 997–98 (concluding first that "DNA forensic identification tests to determine exclusion are reliable and meet the *Frye* standard of admissibility" but later deeming the DNA identification evidence inadmissible as a matter of law).

96. *See e.g.*, United States v. Jakobetz, 955 F.2d 786, 794–96 (2d Cir. 1992) (discussing *Castro* and *Two Bulls* and applying a more liberal standard to DNA evidence); United States v. Two Bulls, 918 F.2d 56, 59 (8th Cir. 1990) (adopting *Castro*'s Prong III analysis and justifying the addition to the *Frye* test because of the novelty of DNA evidence and the potential prejudice to the defendant); State v. Pennington, 393 S.E.2d 847, 854 (N.C. 1990) (discussing *Castro* and upholding the admission of forensic DNA technology under a modified *Frye* standard similar to that used in *Castro*); Cobey v. State, 559 A.2d 391, 392–99 (Md. Ct. Spec. App. 1991) (discussing Maryland's DNA admissibility procedure); People v. Axell, 235 Cal. App. 3d 836, 860–63 (Cal. Ct. App. 1991) (discussing *Castro* and upholding the admission of forensic DNA technology under a modified *Frye* standard similar to that used in *Castro*); State v. Pennell, 584 A.2d 513, 516–20 (Del. Super. Ct. 1989) (same).

97. *See supra* note 96 (listing cases in several jurisdictions that treated DNA evidence differently post-*Castro*).

98. *See* R. Michael Sweeney, Comment, *DNA Typing: Defending a Process Under Vigorous Attack*, 21 CAP. U. L. REV. 611, 629–30 (1992) (discussing *Castro* and its aftermath and noting that several jurisdictions began using a modified *Frye* standard and held *Frye* hearings to determine the admissibility of novel DNA techniques).

the court created an arguably more stringent standard than the *Frye* test. The *Castro* test required both *Frye*'s general acceptance throughout the scientific community as well as an additional analysis by the court to ensure the specific techniques used with DNA evidence independently met the *Frye* standard.[99] Specifically, in Prong III, the court suggested judges conduct pre-trial hearings to consider whether "the testing laboratory in the particular case yielded results sufficiently reliable to be presented to the jury."[100] Others have argued, however, that this Prong III analysis "relates more to the weight of the evidence than to traditional concerns over admissibility" because reliability of evidence is a concept typically within the province of the jury.[101]

Three years later in *People v. Wesley*,[102] a New York court declined to follow *Castro* stating, "the theory underlying forensic DNA fingerprinting has gained acceptance in the scientific community. . . . [T]his conclusion is no longer subject to much dispute."[103] *Wesley* specifically dismissed the idea of imposing additional or "more stringent" requirements for novel and complex peculiarities attendant to DNA testing.[104] *Wesley*'s ultimate dismissal of the *Castro* reasoning does not undermine the fact that initially, faced with a new technology, some courts treated complex scientific evidence differently. As DNA

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99. *See* Patton, *supra* note 78, at 230 (discussing the Prong III requirement).

100. People v. Castro, 545 N.Y.S.2d 985, 998 (Sup. Ct. 1989).

101. Patton, *supra* note 78, at 230.

102. 589 N.Y.S.2d 197 (N.Y. App. Div. 1992).

103. *Id.* at 200.

104. *See id.* at 199 n.2

> We are aware that several tribunals which follow the *Frye* standard for admissibility of novel scientific evidence . . . have declined to adopt it in the context of DNA fingerprint evidence, claiming that the relative novelty of the theory and the complexity of the testing procedures require a more stringent test which includes, in addition to satisfying the *Frye* test, a showing that accepted procedures actually were followed in testing the *subject samples,* thus rendering the results reliable. While cognizant of the fact that the *Frye* test recently has been called into question as an across-the-board standard for judging the admissibility of *all* types of scientific evidence in this instance we are not persuaded that the peculiarities attendant to DNA testing render the *Frye* test inadequate.

(citations omitted).

technology continues to change, courts should continue to carefully analyze and assess the reliability and admissibility of the new and complex DNA technologies.

*2. Post-*Daubert *Admissibility of DNA Evidence*

Starting in the mid-1990s, courts began admitting DNA identification evidence based on restriction fragment length polymorphism (RFLP) and polymerase chain reaction (PCR) typing, methods courts still widely accept today.[105] In conjunction with admitting the RFLP and PCR typing, courts today typically admit the statistical calculations that aid in deciphering the typing results. Without the statistics providing the probability assessment, the jury has no way of understanding the matching profiles.[106] Persuasive statistics usually carry an immense weight

105. *See* United States v. Beasley, 102 F.3d 1440, 1444–48 (8th Cir. 1996) (applying the *Daubert* standard and concluding "that the reliability of the PCR method of DNA analysis is sufficiently well established to permit the courts of this circuit to take judicial notice of it in future cases"), *cert. denied*, 520 U.S. 1246, 1246 (1997); United States v. Davis, 40 F.3d 1069, 1072–75 (10th Cir. 1994) (applying the *Daubert* standard and concluding the trial court properly determined the methodology for DNA testing and properly applied that methodology to the facts in issue), *cert. denied*, 514 U.S. 1029, 1029 (1995); United States v. Bonds, 12 F.3d 540, 549–68 (6th Cir. 1993) (discussing in detail the proper admissibility analysis for DNA evidence and concluding that the DNA evidence "easily meets the more liberal test set out by the Supreme Court in *Daubert*"); United States v. Shea, 957 F. Supp. 331, 345–46 (D. N.H. 1997) (denying defendant's motion to exclude DNA evidence and finding PCR method of DNA testing reliable and admissible under the *Daubert* standard), *aff'd*, 159 F.3d 37, 41 (1st Cir. 1998), *cert. denied*, 526 U.S. 1077, 1077 (1999); United States v. Jakobetz, 747 F. Supp. 250, 255, 263 (D. Vt. 1990) (acknowledging that "most all of the state trial and appellate courts that have confronted the issue have held that DNA profiling is generally admissible" and holding that DNA profiling is admissible to prove identity), *aff'd*, 955 F.2d 786, 807 (2d Cir. 1992), *cert. denied*, 506 U.S. 834, 834 (1992).

106. *See* United States v. Yee, 134 F.R.D. 161, 181 (N.D. Ohio 1991) ("[W]ithout the probability assessment, the jury does not know what to make of the fact that the patterns match: the jury does not know whether the patterns are as common as pictures with two eyes, or as unique as the Mona Lisa."); Thompson, *Controversial Forensic DNA Statistics*, *supra* note 4, at 13 ("Courts in most jurisdictions will not admit DNA evidence unless it is accompanied by statistics to give meaning to the finding of a match.").

with a jury.[107] The certainty of the statistics may affect the court's admissibility analysis.[108]

Over the past twenty years, courts have continued to identify substantive factors affecting DNA's admissibility. For example, similar to the issue in *Castro*, laboratories must use certain standards and procedures during testing.[109] If the laboratory does not comply with these specific standards, the results may be inaccurate, and the sample may be inadmissible.[110] As a procedural matter, a court continues to require the prosecution to prove both the general acceptance of the DNA technology as well as its reliability.[111] This requirement usually boils down to a battle of the experts.[112] The prosecution may need to subpoena multiple experts, including the laboratory technician who conducted the test.[113] Courts widely accept, as scientifically reliable, the underlying RFLP and PCR methods. Therefore, defense attorneys typically challenge the evidence in other ways such as any purported bias of the prosecution's witnesses, inaccurate standards or procedures, a laboratory's poor performance, or the liberality of match criteria applied in the particular case.[114]

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107. *See* Martinez v. Florida, 549 So. 2d 694, 694–97 (Fla. Dist. Ct. App. 1989) (acknowledging the impact of DNA and acknowledging other courts exclude statistical DNA evidence involving very large numbers due to their potentially exaggerated effect on the jury).

108. *See id.* (analyzing the exaggerated effect of DNA statistical evidence on the jury but ultimately concluding the average jury can weigh the credibility of such figures when they are properly presented and challenged, and that statistical evidence is acceptable if it has an adequate scientific and factual basis).

109. *See* United States v. Lowe, 954 F. Supp. 401, 414–16 (D. Mass. 1996) (discussing laboratory standards in the forensic community).

110. *See id.* at 419 (noting that failure to meet laboratory standards—particularly contamination—could affect the reliability of the results obtained).

111. Laurel Beeler & William R. Wiebe, Comment, *DNA Identification Tests and the Court*, 63 WASH. L. REV. 903, 939–45 (1988).

112. *See id.* (discussing expert testimony).

113. *Id.*

114. *See id.* at 941, 943 n.202 (discussing defense experts and their arguments).

III. Understanding DNA as Scientific Evidence

A basic understanding of DNA, DNA typing methods, and human and computer statistical interpretation methods is needed in order to understand an admissibility analysis of DNA evidence interpreted by TrueAllele. Part III discusses the scientific development of these DNA techniques and compares and contrasts the widely used human interpretation DNA analysis with the new TrueAllele technology.

A. The Basic Principles of DNA

DNA and its technology is complicated. Most judges, lawyers, and jurors do not have the scientific background required to fully understand forensic science.[115] Despite this lack of understanding in the courtroom, DNA is nevertheless considered a "powerful evidentiary tool[,] and its importance in the courtroom cannot be overstated."[116]

To understand the different methods of DNA identification techniques and their interpretation, it is helpful to first grasp some basic principles and terms.[117] Deoxyribonucleic acid (DNA) molecules are long threadlike structures resembling a twisted "ladder."[118] DNA is located in the chromosomes, which are in the nucleus of a cell.[119] The sides of the ladder are composed of a chain of sugars and phosphates.[120] The "rungs" or "teeth" attached to the ladder consist of pairs of molecules called "bases."[121] The bases include adenine, cytosine, guanine, and

115. *See* Thompson & Ford, *DNA Typing*, *supra* note 7, at 52–54 (discussing the challenges and complexity of DNA typing).

116. *See* Whack v. State, 433 Md. 728, 732 (2013) (citing *Maryland v. King*, 133 S. Ct. 1958, 1966 (2013), which observed that DNA technology is "one of the most significant scientific advancements of our era" and its usefulness in the criminal justice system is "undisputed").

117. For a more detailed description of the DNA paradigm, see JAMES D. WATSON ET AL., MOLECULAR BIOLOGY OF THE GENE (7th ed., 2013). For a lawyer-friendly basic introduction to DNA, see LARRY GONICK & MARK WHEELIS, THE CARTOON GUIDE TO GENETICS (1991).

118. Thompson & Ford, *DNA Typing*, *supra* note 7, at 62.

119. *Id.* at 61 n.76.

120. *Id.* at 62.

121. *Id.*

thymine (A, C, G, and T, respectively).[122] Each base bonds with one other base to make up the rung. The order of the bases along the DNA molecule creates an organism's genetic code.[123]

DNA analysis unravels the genetic alphabet from a chromosome's hundred million letters and zooms in to a small region of approximately 100 to 500 letters.[124] Most sections of the chain of bases are the same among individuals within a given species, but certain sections are unique (also known as variable or "polymorphic").[125] Zooming in on these unique sections provides highly variable data useful for identifying people.[126] In addition, sometimes a "gene" (a sequence of bases responsible for producing a particular protein) will produce two or more possible variations called "alleles."[127] These variations cause different physical expressions of the gene. For example, the human gene responsible for the production of blood is polymorphic and produces different alleles, resulting in a number of different blood types in the human population.[128]

Due to these unique polymorphisms, no two individuals (except for identical twins) have identical base sequences throughout their DNA.[129] At the same time, no person's base sequence within a particular section is absolutely unique compared to the rest of the population.[130] A person's DNA remains the same throughout life[131] and can be tested using a variety of biological materials.[132] DNA identification of a specific

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122. *Id.*

123. *Id.*

124. *See* Mark Perlin, *When Good DNA Goes Bad*, J. FORENSIC RES., Apr. 2013, at 1 [hereinafter Perlin, *When Good DNA Goes Bad*] (describing the genotype).

125. Thompson & Ford, *DNA Typing*, *supra* note 7, at 62.

126. *See* Perlin, *When Good DNA Goes Bad*, *supra* note 124, at 1 ("This genetic location, or 'locus,' could describe meaningful information like a functional gene, or, alternatively, its DNA letters could code for something more random.").

127. Thompson & Ford, *DNA Typing*, *supra* note 7, at 62.

128. *See id.* at 51 (discussing ABO typing, a genetic identification technique, and its limitations).

129. *Id.* at 61.

130. *Id.* at 63.

131. *Id.* at 61.

132. *See* Keith A. Findley, *New Laws Reflect the Power and Potential of*

person, therefore, is not perfect and typically operates only to a practical exclusion of others.[133]

B. Genetic Identification: Methods of DNA Typing

After collecting a DNA sample, a laboratory technician engages in the process of isolating and producing a DNA result for interpretation.[134] This process is typically called "DNA fingerprinting."[135] Two methods of DNA fingerprinting emerged in the mid-1980s. The first method is called restriction fragment length polymorphism analysis.[136] The second technique of DNA fingerprinting is called polymerase chain reaction.[137]

Both the PCR and RFLP processes are vulnerable to producing "artifacts."[138] Artifacts are inaccurate or invalid results that can be caused by contamination or laboratory failures.[139] For example, RFLP analysis may suffer from "band shifts," an unexplained phenomenon in which DNA fragments in one lane of a gel migrate at a rate different from identical fragments in other lanes of the same gel.[140] Band shifts have the effect of producing inaccurate results that may incorrectly implicate a defendant.[141] Similarly, PCR analysis may suffer from "shadow peaks."[142]

DNA, 75 WIS. LAW 20, 23 (2002) (discussing the biological materials that house DNA including hair follicles, blood, semen, and other tissues).

133. *See* Thompson & Ford, *DNA Typing*, *supra* note 7, at 52 (discussing statistical issues of matching DNA type in the population and the probability of a coincidental match between two unrelated individuals).

134. *See* Sue Rosenthal, Note, *My Brother's Keeper: A Challenge to the Probative Value of DNA Fingerprinting*, 23 AM. J. CRIM. L. 195, 198 (1995) (discussing the initial extraction and analysis of DNA).

135. *See id.* at 199 (introducing the concept of a DNA "fingerprint").

136. *See* George Bundy Smith & Janet A. Gordon, *The Admission of DNA Evidence in State and Federal Courts*, 65 FORDHAM L. REV. 2465, 2468 (1997) (introducing the RFLP technique).

137. *See id.* at 2470 (introducing the PCR technique).

138. *See id.* at 2471 (discussing the disadvantages to PCR and RFLP analysis).

139. *Id*.

140. *See* Judith A. McKenna, Joe S. Cecil & Pamela Coukos, *Reference Guide on Forensic DNA Evidence*, FEDERAL JUDICIAL CENTER, at 295–96, https://bulk.resource.org/courts.gov/fjc/sciam.9.dna.pdf (defining band shifting).

141. *Id.* at 296.

142. *See* Smith & Gordon, *supra* note 136, at 2471 (discussing how PCR

Shadow peaks are allelic peaks, usually with a low number of relative fluorescent units that do not actually exist in a DNA profile but appear as an inaccurate result of the PCR amplification.[143] Although (quantitative) human interpretation of DNA typically accounts for shadow peaks, a (qualitative) computerized interpretation of DNA may not.[144] In addition, when experts attempt to produce a DNA fingerprint from samples that contain too little DNA or DNA that is too degraded, the results of the DNA test can be unreliable, even when using PCR analysis.[145] Degraded samples may cause the analysis to fail to detect certain genetic characteristics; a phenomenon called "allelic dropout" may result in similar inaccurate consequences.[146]

C. Human Interpretation of DNA Profiles

Once a laboratory obtains a DNA fingerprint from the sample provided, the prosecution will provide the laboratory with a DNA fingerprint from the defendant. A technician must then demonstrate that the results from the sample match and identify that particular defendant.[147] The expert makes this identification

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methodology is susceptible to error and can lead to amplification of the wrong DNA).

143. *Id.*

144. *Infra* Part III.C–D.

145. *See* Thompson, *Controversial Forensic DNA Statistics*, *supra* note 4, at 12 (discussing unreliable DNA results).

146. Allelic "dropout" occurs when an allele is present at a locus but not detected due to "background noise." *See id.* at 14 (discussing stochastic effects). Allelic dropout may be caused by using samples that contain too little DNA, frequently referred to as low-copy number samples because these samples contain a low number of copies of the targeted DNA. *Id.* Basically, when the DNA collected is degraded or mixed, the PCR test can distort the result. *Id.* The test might drop alleles entirely or pick up extra alleles that should not be there (where the dropping phenomenon is called "stutter" and the peaks are referred to as "shadow peaks"). *Id.* The more distorted the test results, the less accurate the interpretation of those results. In other words, inaccurate duplication of DNA may yield false positives that can give the impression of enhanced probability. For more information on LCN typing, see BRUCE BUDOWLE ET AL., LAB. DIV. OF THE FED. BUREAU OF INVESTIGATION, LOW COPY NUMBER: CONSIDERATION AND CAUTION, LAB. DIV. OF THE FED. BUREAU OF INVESTIGATION (2001), http://www.promega.com/~/media/files/resources/conference%20proceedings/ishi%2012/oral%20presentations/budowle.pdf?la=en.

147. *See Lawyer's Guide to Forensic Statistics: Technical Bulletin 40-021*, at

through statistical assumptions.[148] The statistics give meaning to the finding of a DNA "match."[149]

Laboratories that conduct human analysis of DNA mixture samples follow an all-or-nothing approach.[150] If an allelic peak falls above a certain threshold, it will be counted as present; if it falls below that threshold, it will be counted as absent.[151] Analysts measure the peak heights and the thresholds in relative fluorescent units.[152] The manual method does not permit an analyst to conclude a probability of a match at a particular allele as anything other than 100% or 0%.[153] If the peak reaches the line, then the peak counts as part of the analysis, and the analysis ends. Due to the low relative fluorescent units of "shadow peaks," human analysis generally excludes these artifacts.[154] In order to cast a wider net, analysts employ different standards to determine the threshold. Sometimes, analysts declare an allelic peak a match if the peak rises above 120 relative fluorescent units, and sometimes the cut off is 80 relative

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1 (Chromosomal Laboratories, Inc., Phoenix, Arizona) http://schooldays 360.wikispaces.com/file/view/LawyerGuidetoForensicStatistics.pdf [hereinafter *Technical Bulletin 40-021*] (giving an overview of DNA statistics); ROBERTO PUCH-SOLIS ET AL., PRACTITIONER GUIDE NO. 2: ASSESSING THE PROBATIVE VALUE OF DNA EVIDENCE: GUIDANCE FOR JUDGES, LAWYERS, FORENSIC SCIENTISTS, AND EXPERT WITNESSES 1–5, 13–14, http://www.maths.ed.ac.uk/~cgga/Guide-2-WEB.pdf (same).

148. *See Technical Bulletin 40-021*, *supra* note 147, at 1 (discussing the requirement of demonstrating that the DNA characteristics are variable among populations).

149. United States v. Yee, 134 F.R.D. 161, 181 (N.D. Ohio 1991).

150. *See* Thompson, *Controversial Forensic DNA Statistics*, *supra* note 4, at 17 ("A more defensible way to deal with problems arising from stochastic effects is for the lab to ignore for statistical purposes any locus where it is suspected that stochastic effects (leading to dropout) may have occurred, whether or not the suspect 'matches' at that locus.").

151. *See id.* ("As a general policy, some labs ignore for statistical purposes any result from a locus where there are peaks below a 'stochastic threshold,' which is often set somewhere between 50 and 150 RFU.").

152. *See id.* ("Peak heights are measured in 'relative fluorescent units' (RFU) and their height can be determined by reference to the vertical indices on an electropherogram.").

153. *See* Mark Perlin, *DNA Done Right*, FHC Experts for Law 5:4-7 (Experts Forum, Essex, UK), 2013, at 5 (describing the incorporation of the Bayes rule into assessing peak height patterns) (on file with the Washington and Lee Law Review).

154. *See supra* notes 138–146 and accompanying text (discussing artifacts).

fluorescent units. Employing different thresholds may yield different results.[155] Ultimately, forensic science labs commissioned studies to establish and validate stochastic and analytical thresholds in order to eliminate this subjectivity.[156] At the same time, the field also sought ways to improve statistical calculations in mixture cases by utilizing computer analysis and incorporating the Likelihood Ratio approach.[157]

Different DNA profiles require different statistical treatment.[158] For example, DNA mixture profiles (DNA samples that include more than one contributor)[159] create unique analytical and statistical challenges.[160] In 2006, the International Society of Forensic Genetics issued a consensus document "to define a generally acceptable mathematical approach for typical mixture scenarios and to address open questions where practical and generally accepted solutions do not yet exist."[161]

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155. *See* Thompson, *Controversial Forensic DNA Statistics*, *supra* note 4, at 17 (discussing stochastic thresholds and admitting "'stochastic thresholds' are not a perfect solution . . . to unreliable DNA because . . . experts disagree about what the 'stochastic threshold' should be").

156. *See* Erin Murphy, *The Art in the Science of DNA: A Layperson's Guide to the Subjectivity Inherent in Forensic DNA Typing*, 58 EMORY L.J. 489, 503–04 (2008) (describing the importance of peak-height thresholds).

157. *See* Gill, *ISFG Recommendations*, *supra* note 161, at 90–101 (proposing a statistical method that takes dropout probabilities into account).

158. *See Technical Bulletin 40-021*, *supra* note 147, at 1 (discussing valid statistical treatments applied appropriately in different situations).

159. *See* Peter M. Schneider et al., *Editorial on the Recommendations of the DNA Commission of the ISFG on the Interpretation of Mixtures*, 160 FORENSIC SCI. INT'L 89, 89 (2006) (discussing DNA mixture profiles); Mark W. Perlin, Explaining the Likelihood Ratio in DNA Mixture Interpretation 7–8 (Dec. 29, 2010) (unpublished manuscript) [hereinafter Perlin, *Explaining LR*] (discussing and defining DNA mixtures) (on file with the Washington and Lee Law Review).

160. *See* Schneider et al., *supra* note 159, at 89 ("The biostatistical interpretation of . . . mixed DNA profiles is a very challenging task that sometimes leads to controversial views about correct mathematical approaches for estimating the weight of the evidence.").

161. Peter Gill et al., *DNA Commission of the International Society of Forensic Genetics: Recommendations on the Interpretation of Mixtures*, 160 FORENSIC SCI. INT'L 90, 90 (2006) [hereinafter Gill, *ISFG Recommendations*].

D. Computer Interpretation of DNA Profiles: TrueAllele

In 1994, a private company called Cybergenetics began commercializing a computerized DNA interpretation technology called TrueAllele.[162] TrueAllele debuted in the United States in 2002.[163] The New York State Police published two National DNA Index System validation studies and ultimately incorporated TrueAllele into its Department of Forensic Science.[164] In 2006, Cybergenetics received a contract to reanalyze and reinterpret the DNA of victims' remains from the September 11, 2001 World Trade Center terrorist attack.[165] In 2009, TrueAllele made its first appearance in a United States courtroom in the murder case of *Commonwealth v. Foley*.[166]

Cybergenetics markets TrueAllele as an automated system for interpreting DNA evidence.[167] Computer analysis like TrueAllele is not a substitute for the DNA collection or amplification process. Instead, the process remains the same until the point of the DNA statistical analysis. In other words, law enforcement still collects the sample, submits it to the Department of Forensic Science laboratory, and the lab uses traditional amplification processes to produce data suitable for

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162. *See History of Cybergenetics*, CYBERGENETICS, http://www.cybgen.com/company/history.shtml (last visited Mar. 20, 2015) (describing the history of Cybergenetics and TrueAllele) (on file with the Washington and Lee Law Review).

163. *Id.*

164. *Id.*; *see also New York State Police to Deploy FBI Approved TrueAllele Expert System for DNA Review*, BUSINESS WIRE (Nov. 28, 2006), http://www.cybgen.com/information/press-release/2006/New-York-State-Police-to-Deploy-FBI-Approved-TrueAllele-Expert-System-for-DNA-Review/page.shtml (last visited Mar. 20, 2015) (discussing New York State Police acceptance of TrueAllele) (on file with the Washington and Lee Law Review).

165. *History of Cybergenetics*, CYBERGENETICS, http://www.cybgen.com/company/history.shtml (last visited Mar. 20, 2015) (on file with the Washington and Lee Law Review).

166. *See* Commonwealth v. Foley, 38 A.3d 882, 888–90 (Pa. Super. Ct. 2012) (discussing the admissibility of TrueAllele as a novel scientific method that Mr. Foley claimed "ha[d] never been used in court"); *infra* Part IV.A.2 (discussing *Commonwealth v. Foley*).

167. *History of Cybergenetics*, CYBERGENETICS, http://www.cybgen.com/company/history.shtml (last visited Mar. 20, 2015) (on file with the Washington and Lee Law Review).

statistical interpretation.[168] At that point, however, the laboratory forwards the sample to Cybergenetics, and Cybergenetics conducts the interpretation.[169] Alternatively, some forensic labs may have TrueAllele software on-site, and will conduct their own analysis.[170] Instead of traditional human analysis where a person manually examines the allelic peaks, the TrueAllele operator inputs the DNA fingerprint into the computer program. The program, in turn, subjects that data to a computer analysis.

The developer of TrueAllele, Dr. Mark Perlin, aimed to create an analysis technology that could "easily analyze and interpret DNA data rapidly and cost effectively, while reducing human error."[171] More recently, Dr. Perlin has focused on adapting TrueAllele to analyze and interpret mixed DNA samples with multiple contributors.[172]

The TrueAllele computer program relies on a form of statistical analysis called probabilistic genotyping.[173] Probabilistic genotyping involves applying the information derived from DNA profiles to complex mathematical formulas known as algorithms.[174] The algorithms compare different statistical models to the actual data and weigh the probability that the model matches the data.[175] Using that probability,

168. *See id.* (describing TrueAllele as an "interpretation" method, and not a DNA typing technology).

169. *See Sending Data*, CYBERGENETICS, http://www.cybgen.com/support/sending_data.shtml (last visited Mar. 20, 2015) (discussing TrueAllele's protocol for sending and processing laboratory's data) (on file with the Washington and Lee Law Review).

170. *See* JO ANN GIVEN ET AL., FORENSIC SCIENCE BASED ANNUAL REPORT 4 (2013) (giving an example of one state that acquired the TrueAllele software in their own laboratories in order to generate their own calculations).

171. *History of Cybergenetics*, CYBERGENETICS, http://www.cybgen.com/company/history.shtml (last visited Mar. 20, 2015) (on file with the Washington and Lee Law Review).

172. *See id.* ("Working with some of the foremost laboratories in forensics, Cybergenetics began to develop technology that could analyze and interpret complex mixed crimes scene DNA in a matter of minutes.").

173. Perlin, *When Good DNA Goes Bad*, *supra* note 124, at 3.

174. *Id.*

175. *Id.*

technicians can further compute a likelihood ratio using traditional statistical methods.[176]

Specifically, TrueAllele relies on a class of algorithms derived from a Bayesian statistical analysis called Monte Carlo-Markov Chain (MCMC) modeling.[177] The MCMC statistical approach has been used in a variety of situations to successfully model many complex data sets;[178] however, MCMC's application to forensic DNA is arguably new and unique to TrueAllele.[179]

IV. The Admissibility of TrueAllele

A. TrueAllele Precedent

The differences between traditional DNA interpretation and computerized DNA interpretation prompted some courts to examine the admissibility of the new technology. Although *Frye* and *Daubert* lay out clear standards for the admissibility of scientific evidence, applying these standards to new technologies is not always easy.[180] As of right now, only a few cases involve the admissibility of TrueAllele,[181] and courts are still in the process of

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176. *See id.* ("The computer records an evidence genotype as a probability distribution. Afterwards, the computer can then make an objective comparison to a known reference genotype obtained from a suspect or some other person.").

177. *See* Thompson, *Controversial Forensic DNA Statistics*, *supra* note 4, at 18 (introducing MCMC statistical modeling).

178. *See id.* ("The [TrueAllele] system relies on [MCMC] that has been widely used in the field of statistics to model complex situations.").

179. *See id.* ("Although the application of this technique to forensic DNA testing is novel, the underlying approach has been used successfully elsewhere."). Dr. Perlin previously testified that his system relies on mathematical principles that have been accepted "for 200 years." *See* Transcript of Record, Regina v. Colin Duffy & Brian Shivers, [2011] NICC (Crim) 37, [103] [hereinafter *Duffy & Shivers Transcript*] (describing the underlying principles of TrueAllele as "hav[ing] been in place for at least 200 years") (on file with the Washington and Lee Law Review). Others, however, claim that the use of MCMC in forensic applications was first attempted within the last ten to fifteen years. *See* Thompson, *Controversial Forensic DNA Statistics*, *supra* note 4, at 18 (discussing the novelty of the MCMC approach in forensic applications).

180. *See supra* notes 62–64 and accompanying text (noting the Ninth Circuit's frustration when the court had to apply the *Daubert* factors to the new DNA technology on remand).

181. As this Note was going to print, the Supreme Court of the State of New

creating the body of precedent that will govern the admissibility of evidence analyzed by the new technology.

1. Regina v. Colin Duffy & Brian Shivers

In December 2011, a court in Northern Ireland convicted defendant Brian Shivers of murder in connection with an attack on British soldiers at Massereene Barracks on March 7, 2009.[182] The judge acquitted Mr. Shivers's co-defendant, Colin Duffy, of the same charge.[183] The police allegedly found Mr. Shivers's DNA in two locations on the interior of the backseat of the getaway car.[184] The police also allegedly found Mr. Duffy's DNA on a latex glove tip inside the same car and on the seat buckle, but the

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York for the County of Schenectady, New York released a decision and order finding that "Cybergenetics TrueAllele Casework is not novel but instead is 'generally accepted' under the *Frye* standard." Decision and Order at 13, New York v. Wakefield, No. A-812-29 (Feb. 11, 2015), http://www.cybgen.com/information/admissibility/Wakefield2015.pdf. Accordingly, that court denied the defendant's motion to preclude DNA evidence interpreted by TrueAllele. *Id.* In addition, the court also specifically found:

> (1) that Cybergenetics TrueAllele Casework has been empirically tested and found to be relevant, reliable, and accurate,
>
> (2) that Cybergenetics TrueAllele Casework has been subjected to favorable peer review and extensive publication,
>
> (3) that Cybergenetics TrueAllele Casework's average efficacy has been proved to be at least 4 ½ orders of magnitude more efficacious than human review on the same data,
>
> (4) that Cybergenetics TrueAllele Casework has been validated and found to be reproducible,
>
> (5) that the various scientific principles used by Cybergenetics TrueAllele Casework have been long ago accepted and endorsed by the scientific community, and
>
> (6) that the on-going administrative investigation at the New York State Police Forensic Investigation Center has no bearing on the validation studies performed in July 2013 and/or March 2014 . . . .

Id. at 12–13. Due to the timing of publication, this Note does not analyze this opinion further.

182. *See Brian Shivers Guilty of Massereene Soldiers' Killing*, BBC NEWS NORTHERN IRELAND (Jan. 20, 2012, 6:22 PM), http://www.bbc.co.uk/news/uk-northern-ireland-16637380 (last visited Mar. 20, 2015) (discussing the verdict) (on file with the Washington and Lee Law Review).

183. *Id.*

184. *Id.*

judge ultimately decided the prosecution failed to sufficiently link Mr. Duffy to the murder plot.[185]

In *Duffy*, the prosecution used TrueAllele to analyze the DNA evidence after the traditional interpretation method produced inconclusive results.[186] The admissibility argument over the TrueAllele technology culminated in a three-day voir dire examination of Dr. Perlin and a competing defense expert.[187] Ultimately, the judge admitted the DNA evidence as analyzed by TrueAllele.[188] In that ruling, the judge dismissed several of the defense's objections to the admissibility of the evidence including that Dr. Perlin has a "financial and professional interest in the outcome of the case"[189] and that "Dr. Perlin negligently misled the court upon important aspects of his evidence."[190] Furthermore, the court engaged in a lengthy reliability analysis, crediting Dr. Perlin for giving "very detailed answers [about the TrueAllele technology] in a controlled and measured way."[191] The court noted, however, that it was "regrettable" that the TrueAllele technology had not been subject to greater peer review, although the court did not consider the lack of peer review dispositive for the admissibility analysis.[192]

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185. *Id.*

186. *See* Ruling on Voir Dire at 1, Regina v. Colin Duffy & Brian Shivers, [2011] NICC (Crim) 37 [hereinafter *Duffy & Shivers Voir Dire Ruling*], http://www.cybgen.com/information/newsroom/2011/dec/Shivers2011.pdf (discussing another expert's analysis under the widely accepted SGM+ method of DNA interpretation and how that software did not enable to expert to produce a result).

187. *See generally Duffy & Shivers Transcript*, *supra* note 179.

188. *See Duffy & Shivers Voir Dire Ruling*, *supra* note 186, at 7.

> I am satisfied that the stage has now been reached in the case of this system where it can be regarded as being reliable and accepted, and I am satisfied that Dr. Perlin has given his evidence in a credible and reliable fashion. In the light of these conclusions I can see no basis on which I could properly exercise my discretion under Article 76 of The Police and Criminal Evidence (Northern Ireland) Order 1986 to exclude this evidence, and I therefore admit it in evidence.

189. *Id.* at 3.

190. *Id.* at 4.

191. *Id.* at 8.

192. *See id.* at 11 (discussing TrueAllele's lack of peer review). Please note the judge issued this ruling in 2011. TrueAllele may have undergone additional peer-review in the past four years. In fact, a more recent article notes that TrueAllele has "been used in over a hundred criminal cases with complex DNA

The court also debated the sufficiency of the method by which Dr. Perlin validated the TrueAllele technology—in other words, whether the "wider scientific community" had externally validated the TrueAllele process, as opposed to primarily internal validation.[193] The court noted the parties had different ideas about the appropriate scope of the "relevant scientific community" that should provide the external validation.[194] Dr. Perlin defined the relevant scientific community as "a small group of scholars working in the field of the probabilistic approach."[195] He noted that "[t]he community of scholars who develop DNA methods . . . is about 50 to 100 people, it was a lot smaller 10 to 15 years ago, and these are the groups of people who are responsible for ensuring that reliable methods do get out into the world."[196] The judge also noted that as of 2011, only a

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evidence. . . . [And] [s]even peer-reviewed scientific studies have demonstrated TrueAllele's reliability." *TrueAllele Casework Ruled Admissible in Ohio* Daubert *Challenge*, CYBERGENETICS, http://www.cybgen.com/information/press-release/2014/TrueAllele-Casework-Ruled-Admissible-in-Ohio-Daubert-Challenge/page.shtml (Oct. 22, 2014) (last visited Mar. 20, 2015) (on file with the Washington and Lee Law Review). These studies include:

(1) Mark Perlin & Alexander Sinelnikov, *An Information Gap in DNA Evidence Interpretation*, 4(12) PLOS ONE e8327 (Dec. 16, 2009);

(2) Jack Ballantyne, Erin Hanson & Mark Perlin, *DNA Mixture Genotyping by Probabilistic Computer Interpretation of Binomially-Sampled Laser Captured Cell Populations: Combining Quantitative Data for Greater Identification Information*, 53(2) SCI. & JUSTICE. 81, 103–14 (2013);

(3) Mark Perlin et al., *TrueAllele Genotype Identification on DNA Mixtures Containing up to Five Unknown Contributors*, J. FORENSIC SCIS. (forthcoming 2015);

(4) Susan Greenspoon et al., *Establishing the Limits of TrueAllele Casework: A Validation Study*, J. FORENSIC SCIS. (forthcoming 2015);

(5) Mark Perlin et al., *Validating TrueAllele DNA Mixture Interpretation*, 56(6) J. FORENSIC SCIS. 1407, 1430–47 (2011);

(6) Mark Perlin et al., *New York State TrueAllele Casework Validation Study*, 58(6) J. FORENSIC SCIS. 1413, 1458–66 (2013); and

(7) Mark Perlin et al., *TrueAllele Casework on Virginia DNA Mixture Evidence: Computer and Manual Interpretation in 72 Reported Criminal Cases*, 9(3) PLOS ONE e92837 (2014).

193. *Duffy & Shivers Voir Dire Ruling*, *supra* note 186, at 11.

194. *See id.* (discussing the internal and external validation process of TrueAllele).

195. *Id.*

196. *Id.* at 12.

"very small portion" of laboratories across the world had purchased and incorporated the TrueAllele technology.[197] Despite these findings, however, the judge admitted the DNA evidence as interpreted by TrueAllele.[198] The judge based this decision largely on the New York Commission on Forensic Science DNA Sub-Committee's recommendation that New York should adopt TrueAllele.[199]

2. Commonwealth v. Foley

One of the first cases in the United States to address the admissibility of TrueAllele was *Commonwealth v. Foley*.[200] In that case, a jury convicted Kevin Foley of first-degree murder.[201] Mr. Foley appealed on several issues, including "whether the trial court erred in admitting the testimony of Dr. Perlin, in violation of the *Frye* test for the admissibility of novel scientific testimony."[202] Pennsylvania and a minority of other states still adhere to the *Frye* test.[203] The Superior Court of Pennsylvania defined the *Frye* test as a two-step process:

> First, the party opposing the evidence must show that the scientific evidence is "novel" by demonstrating "that there is a legitimate dispute regarding the reliability of the expert's conclusions." If the moving party has identified novel scientific evidence, then the proponent of the scientific evidence must show that "the expert's methodology has general acceptance in

197. *See id.* at 14 (giving data about the number of laboratories using TrueAllele in the United States, United Kingdom, and Australia).

198. *See id.* at 17 ("I am satisfied that the stage has now been reached in the case of this system where it can be regarded as being reliable and accepted, and I am satisfied that Dr. Perlin has given his evidence in a credible and reliable fashion.").

199. *See id.* at 16–17 (discussing the Commission's validation process).

200. *See* Commonwealth v. Foley, 38 A.3d 882, 890 (Pa. Super. Ct. 2012) (finding the trial court's decision to admit Dr. Perlin's testimony was not an abuse of discretion because "there is no reason to 'impede admissibility of evidence that will aid the trier of fact in the search for truth'").

201. *Id.* at 885.

202. *Id.*

203. *See supra* note 21 and accompanying text (noting that a minority of states use the *Frye* standard today); *see also supra* notes 26–37 and accompanying text (explaining the *Frye* test).

> the relevant scientific community" despite the legitimate dispute.[204]

The superior court acknowledged that the trial court did not expressly determine that Dr. Perlin's testimony or TrueAllele technology was "novel scientific evidence."[205] Instead, the trial court held that Dr. Perlin's new methodology was a refined application of the "product rule," an old method of calculating probabilities.[206] Consequently, because Pennsylvania previously admitted scientific evidence based on the product rule,[207] the trial court admitted Dr. Perlin's testimony and the TrueAllele methodology as generally accepted.[208] In other words, the trial court did not conduct an independent *Frye* analysis for the TrueAllele technology.

The superior court reviewed the trial court's determination for abuse of discretion and found that Dr. Perlin's testimony "was not 'novel' as that term is defined in the governing law, and thus the trial court did not abuse its discretion in admitting the testimony."[209] The superior court explained that "[t]he 'novelty' of scientific testimony turns on whether 'there is a legitimate dispute regarding the reliability of the expert's conclusions,' which is not necessarily related to the newness of the technology used in developing the conclusions."[210] In other words, under *Frye*, if the principle is disputed (even if it is a "bedrock" scientific principle), that principle should be subjected to a *Frye* analysis.[211]

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204. *Foley*, 38 A.3d at 890 (citations omitted).

205. *Id.*

206. *Id.* For more on the "product rule," see *Commonwealth v. Blasioli*, 713 A.2d 1117, 1123–27 (Pa. 1998).

207. *See Blasioli*, 713 A.2d at 1127 (holding that statistical evidence based upon the product rule was properly admitted at the trial court level).

208. *See* Commonwealth v. Foley, 38 A.3d 882, 888 (Pa. Super. Ct. 2012) ("Because Dr. Perlin's calculations were made using newer technology, the trial court rhetorically asked 'at what point does the use of the product rule become novel science.' The trial court went on to find that Dr. Perlin's methodology was generally accepted." (citation omitted)).

209. *Id.*

210. *Id.*

211. *See id.* ("In *Betz*, the court noted that novelty 'is not restricted to new science,' and 'even 'bedrock' scientific principles may be subject to a *Frye* analysis' if those principles become disputed." (citing Betz v. Pneumo Abex L.L.C., 998 A.2d 962, 973–74 (Pa. Super. Ct. 2010))).

However, when there is no dispute, *Frye* should be "construed narrowly so as not to impede admissibility of evidence that will aid the trier of fact in search for truth."[212] Simply put, the superior court found no "legitimate dispute" regarding the reliability of Dr. Perlin's testimony.[213]

Mr. Foley raised, and the court discounted, three reasons for excluding Dr. Perlin's testimony:

> (1) 'as of the date of the pre-trial hearing, no forensic laboratory in the United States used Perlin's TrueAllel [sic] method in analyzing a mixed sample of DNA for forensic purposes;'
>
> (2) 'the TrueAllel [sic] system had never been used in a court of law in any jurisdiction in the United States on a mixed DNA sample to give a likelihood ratio;' and
>
> (3) no outside scientists can replicate or validate Dr. Perlin's methodology because his computer software is proprietary.[214]

The court noted first that novelty alone does not "show 'a legitimate dispute regarding the reliability of the expert's conclusions'"[215] and pointed out the extensive usage of Dr. Perlin's method.[216] The court similarly rejected Mr. Foley's second argument "because 'novelty' of a scientific methodology does not turn on its previous use in court."[217] Finally, the court dismissed Mr. Foley's third argument as "misleading" because "scientists can validate the reliability of a computerized process even if the 'source code' underlying that process is not available to the public."[218] The court concluded that TrueAllele has been tested and validated in peer-review studies.[219]

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212. *Id.*

213. *Id.*

214. *Id.* at 888–89. For more on the requirement to release the TrueAllele source code, see *infra* Part IV.A.3 & IV.B.

215. *Id.* at 889 (citing *Betz*, 998 A.2d at 972).

216. *See id.* (noting the use of TrueAllele technology by New York State, Allegheny County Crime Lab, the World Trade Center, and the United Kingdom's Forensic Science Service).

217. *Id.*

218. *Id.*

219. *See id.* ("Nevertheless, TrueAllele has been tested and validated in peer-reviewed studies.").

3. Ohio v. Shaw

A more recent case addressing the admissibility of TrueAllele in the United States is *Ohio v. Shaw*.[220] Mr. Shaw was indicted for aggravated murder, murder, felonious assault, and kidnapping.[221] The alleged incident occurred on June 6, 2012.[222] DNA evidence was collected at the crime scene from a doorknob and under the victim's fingernails.[223] Both the Cuyahoga County Medical Examiner's Office and Sorenson Genomics, LLC tested the DNA evidence, and the evidence produced inconclusive results.[224] The State then submitted the same DNA material to Cybergenetics for analysis using the TrueAllele technology.[225] TrueAllele produced conclusive results that the State sought to introduce at trial.[226]

Mr. Shaw filed a motion in limine requesting the court exclude any and all evidence related to TrueAllele Casework System pursuant to *Daubert*.[227] Mr. Shaw also filed a motion to compel TrueAllele's source code.[228] Mr. Shaw requested a pretrial hearing on these motions and the court held a hearing on June 30, 2014.[229] At that hearing, two experts—one of which was Dr. Perlin—testified on behalf of the state, and two experts testified on behalf of Mr. Shaw.[230] On October 10, 2014, the Court of Common Pleas in Cuyahoga County, Ohio, issued an order discussing the admissibility of TrueAllele, and ultimately denying Mr. Shaw's motions.[231]

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220. Order, Ohio v. Shaw, CR-13-575691 (Oct. 10, 2014), http://www.cybgen.com/information/press-release/2014/TrueAllele-Casework-Ruled-Admissible-in-Ohio-Daubert-Challenge/admissibility.pdf.

221. *Id.* at 2.

222. *Id.*

223. *Id.*

224. *Id.*

225. *Id.*

226. *Id.*

227. *Id.* at 1.

228. *Id.*

229. *Id.* at 1–2.

230. *Id.* at 2.

231. *Id.* at 25–26.

The testimony at the pretrial hearing primarily focused on two issues: first, whether TrueAllele has been subjected to validation and peer-review, and second, whether that validation is sufficient, given the inability of independent experts to validate the process due to the closed source code.[232] With regards to the validation and peer-review, Dr. Perlin testified that TrueAllele has been validated and there are five published, peer-reviewed validation papers on the TrueAllele Casework System.[233] These papers "go beyond an internal validation."[234] Dr. Perlin also testified that TrueAllele started in the State of New York and gained approval for forensic casework there.[235] The defense expert, Dr. Ranajit Chakraborty, testified that he was a faculty member for the Scientific Working Group on DNA Analysis Methods (SWGDAM), which sets for guidelines for laboratories across the country.[236] As a member of SWGDAM, Dr. Chakraborty testified that he approved TrueAllele for casework in New York State labs in 2011.[237] That approval, however, only extended to TrueAllele testing a higher quantity of DNA from a single source, as opposed to the low quantity of DNA from multiple sources tested in *Shaw*.[238] Overall, Dr. Chakraborty cautioned the court against relying on TrueAllele's results given the complications of testing such low quantities of mixed DNA.[239] Dr. Chakraborty also testified that TrueAllele is not generally accepted in the scientific community and has not been subjected to rigorous peer-review because none of the validations completed on TrueAllele gave full details of the scenarios of the cases examined.[240]

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232. *See id.* at 6–19 (discussing the testimony of the four witnesses).

233. *Id.* at 8.

234. *Id.* at 8–9.

235. *Id.* at 10–11.

236. *Id.* at 15.

237. *Id.*

238. *Id.* The order notes that "[o]n cross examination, [Dr. Chakraborty] acknowledged that the samples were mixtures of up to three people; some known and some unknown." *Id.*

239. *See id.* at 14–15 ("From his research, [Dr. Chakraborty] has to be very careful about typing low copy number DNA or low input DNA samples particularly if these samples contain DNA mixture from multiple individuals.").

240. *Id.* at 15.

With regards to the closed source code, Dr. Chakraborty testified that, in his opinion, an independent party could not recreate or validate TrueAllele results without the source code.[241] A second defense expert, Dr. Krane, testified that one important part of the scientific method is reproducibility.[242] In other words, scientists must publish not only their results, but describe how they got to those results.[243] Dr. Krane testified that TrueAllele has not disclosed this process.[244] In addition, Dr. Krane testified that separate from the validation issue, the source code may be necessary for confrontation and accountability as well.[245] Dr. Perlin testified that a scientist "can get very close to duplicating his work by reading his work. But if the scientist has not purchased the system he cannot duplicate it because he does not have all of the engineering details."[246] Finally, Dr. Perlin testified that the reliability of the source code is determined by testing and validation studies, not by reading the text of the source code itself.[247]

The trial court considered the *Daubert* factors and concluded that "[b]oth the internal validation studies and peer review articles support the position that the TrueAllele Casework System has been tested."[248] The court further found, given the admission of TrueAllele in other jurisdictions, and the use of the technology in three laboratories, the new technology satisfies the "general acceptance" factor.[249] Ultimately, the court found that "[b]ased on its consideration of the liberal factors set forth in *Daubert*[,] . . . the State's expert witness and the TrueAllele System are reliable and, therefore, admissible . . . [and] the expert's testimony is a matter of weight for the jury to consider."[250]

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241. *Id.* at 15–16.
242. *Id.* at 17.
243. *Id.*
244. *Id.*
245. *Id.* at 19.
246. *Id.* at 12.
247. *Id.*
248. *Id.* at 20.
249. *Id.* at 21–24.
250. *Id.* at 25.

B. TrueAllele Admissibility Issues

The cases discussed above include several defense challenges to the admissibility of TrueAllele. In *Foley*, the defense attacked the "novelty" of the technology under the *Frye* standard.[251] As TrueAllele continues to refine its technology, and courts continue to admit more qualitative interpretations of DNA evidence, the "novelty" challenge will become less persuasive. As seen in *Shaw*, one current objection to computerized DNA typing technologies is the inability to properly evaluate the scientific community's acceptance of the technology.[252] This concern rises from the fact that the commercial companies developing the technologies employ confidential laboratory protocols to protect alleged trade secrets.[253] In their article *DNA Typing: Acceptance and Weight of the New Genetic Identification Tests*, William Thompson and Simon Ford point out that asserting a company's procedures involve trade secrets essentially "shield[s] [the companies] from scrutiny by the scientific community at large."[254] This assertion places companies in a contradictory position: on the one hand, the companies want admissibility for their tests and argue that their procedures are sufficiently known and proven to be generally accepted by the scientific community.[255] On the other hand, the companies want to keep their methods confidential.[256] Thompson

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251. *See* Commonwealth v. Foley, 38 A.3d 882, 888–90 (Pa. Super. Ct. 2012) (engaging in a "novelty" analysis under *Frye*).

252. *See* Order at 6–19, Ohio v. Shaw, CR-13-575691 (Oct. 10, 2014), http://www.cybgen.com/information/press-release/2014/TrueAllele-Casework-Ruled-Admissible-in-Ohio-Daubert-Challenge/admissibility.pdf (including testimony from conflicting experts disputing the scientific community's acceptance of TrueAllele).

253. *See* Thompson & Ford, *DNA Typing*, *supra* note 7, at 59 ("Efforts to evaluate scientific acceptance of a particular implementation of DNA typing technology may be hindered, however, by the desire of commercial laboratories to keep their laboratory protocols confidential in order to protect alleged trade secrets.").

254. *Id.* at 59–60.

255. *See id.* (discussing how companies "seek admissibility for their tests, arguing that their procedures are sufficiently known and proven to be regarded as generally accepted by the scientific community").

256. *See id.* (discussing how companies "seek to keep their tests confidential, arguing that they contain procedures or processes sufficiently unique and innovative to constitute trade secrets").

and Ford warn that "[c]ourts would be well advised to tell these companies that they cannot have it both ways. If [the companies] wish to assert that their procedures are accepted, they must open themselves to scrutiny by the scientific community so that their assertion can be put to the test."[257]

Another issue surrounding TrueAllele's admissibility is the risk of human manipulation of the data entered into the computer program and manipulation of the results produced. Inputting data into the TrueAllele software requires certain assumptions, such as the number of contributors to the DNA profile.[258] In *Duffy* and *Shaw*, the experts disputed the exact number of contributors.[259] Arguably, the number of contributors may affect the accuracy of the results.

In addition to the human manipulation of the data entered into the system, TrueAllele, like all DNA statistical interpretations, is susceptible to human manipulation of the results. As discussed above, the TrueAllele system relies on a method of random statistical modeling.[260] The randomization varies with every test run.[261] In *Duffy*, Dr. Perlin ran the evidence sample four separate times in the TrueAllele system, producing four different likelihood ratios for incriminating the defendant: 389 million, 1.9 billion, 6.03 billion, and 17.8 billion.[262]

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257. *Id.*

258. *See Duffy & Shivers Transcript*, *supra* note 179, at 37 ("[W]e'll . . . make different assumptions which is required for any likely ratio [including the number of contributors].").

259. *See* [2011] NICC (Crim) 37, at 51 ("[W]e'll . . . [assume] I suppose there are two contributors if there's clearly two contributors, fine, if there might be three, we'll assume both two and three and produce values for all, for all possibilities considered."); Order at 18, Ohio v. Shaw, CR-13-575691 (Oct. 10, 2014), http://www.cybgen.com/information/press-release/2014/TrueAllele-Casework-Ruled-Admissible-in-Ohio-Daubert-Challenge/admissibility.pdf. (Dr. Krane) (testifying that he reviewed a report that suggested that there was empirical evidence to support the conclusion that there are at last three contributors to that DNA mixture, not two contributors as input by TrueAllele) (on file with the Washington and Lee Law Review).

260. *See supra* Part III.D (discussing MCMC, the statistical modeling of TrueAllele).

261. *See Duffy & Shivers Transcript*, *supra* note 179, at 108 ("[I]f what you see is two identical traces then there is almost certainly human error because you are not going to see the same results twice unless you are using Photoshop or somebody made a mistake, you expect random variation.").

262. *See* Thompson, *Controversial Forensic DNA Statistics*, *supra* note 4, at

Ultimately, Dr. Perlin used the 6.03 billion result in court and discarded the lower results.[263] The practical implication is that the 6.03 billion result made it more likely the sample belonged to the defendant than the 389 million or 1.9 billion results.[264] Defense attorneys may argue there are no standards or protocols to direct when Dr. Perlin should pick certain results over others. Cybergenetics has suggested, however, that prosecutors "[n]ever accept a DNA match result of under a million-to-one as definitive [because] [m]ore sophisticated interpretations can be done."[265] According to Cybergenetics' own suggestion, all three of Dr. Perlin's results in *Duffy* (ranging from 389 million- to 17.8 billion-to-one) would fall well within this standard. In addition, since *Duffy*, Cybergenetics has clarified its position on allowing juries and judges to see multiple DNA statistics: "It is perfectly acceptable for juries and judges to see multiple DNA match statistics. Reasonable people understand that using more of the data gives more information."[266]

V. TrueAllele and the Norms of Criminal Procedure: What is the Proper Admissibility Analysis?

As seen in *Duffy*, *Foley*, and *Shaw*, courts structure their admissibility analysis of TrueAllele around "reliability."[267] But

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20 (discussing the four different likelihood ratios that correspond to the four separate times TrueAllele ran its software on a particular electropherogram).

263. *See Duffy & Shivers Transcript*, *supra* note 179, at 122–23 (presenting a likelihood ratio of 6.01 billion-to-one).

264. *See* Thompson, *Controversial Forensic DNA Statistics*, *supra* note 4, at 20 ("These varying results illustrate the issue of reproducibility discussed above—they show that there is an element of uncertainty (a margin of error) in the likelihood ratios generated by the system.").

265. *Same Data, More Information: Murder, Match and DNA*, THE DNA INVESTIGATOR (Cybergenetics, Philadelphia, PA), Fall 2009, at 3, http://www.cybgen.com/information/publication/2009/newsletter/Perlin-Same-Data-More-Information-Murder-Match-and-DNA/newsletter.pdf (on file with the Washington and Lee Law Review).

266. *Id.*

267. *See* Commonwealth v. Foley, 38 A.3d 882, 888 (Pa. Super. Ct. 2012) ("Here, we find no legitimate dispute regarding the *reliability* of Dr. Perlin's testimony.") (emphasis added); *Duffy & Shivers Voir Dire Ruling*, *supra* note 186, at 10 ("Fundamental to the admissibility of any scientific concept of this type is whether it is *reliable* and that has to be adequately validated . . . .").

reliability is a flexible concept: sometimes focusing on the accuracy of the results, sometimes on the process leads to those results, and sometimes on what the relevant scientific community think about the process and results.[268] The multiple dimensions of the reliability analysis spring from the interplay between two bedrock principles of criminal law and procedure: accuracy and fairness.[269]

Ultimately, there is an inherent difficulty courts must manage when deciding whether to admit TrueAllele DNA interpretations because assessing the reliability of evidence requires courts examine *both* what is fair and what is accurate.[270] Are TrueAllele DNA interpretations reliable just because they are accurate? Is the process of TrueAllele fair to the defendant if the defendant may not be able to read the source code or directly reproduce results without purchasing the software? What if defense attorneys do not have the resources or information they need to make challenges to the technology? These are all questions that courts should grapple with when examining TrueAllele. Courts will inevitably have difficulty answering these questions because the two norms, accuracy and fairness, are inextricably linked.[271] In other words, once accuracy is identified as a requirement, it is much more difficult for courts to give independent weight to a fairness requirement.[272] The admissibility of TrueAllele may hinge on the court's emphasis on one norm over another. At a minimum, courts should strive to consider and balance both norms in their analysis of the admissibility of computerized DNA technologies.

Keeping these norms in the forefront of their minds, judges should engage in a dialogue, similar to that in *Castro*, with both

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268. *See supra* notes 12–17 and accompanying text (discussing the different definitions of reliability).

269. *See* DRESSLER & THOMAS, CRIMINAL PROCEDURE, *supra* note 10, at 36–38 (discussing accuracy and fairness).

270. *See id.* (giving additional examples of the interplay between fairness and accuracy such as the admissibility of coerced confessions and interrogation techniques, the right to remain silent, and the heavy beyond a reasonable doubt standard).

271. *See id.* at 38 (discussing the interplay between fairness and accuracy).

272. *See id.* ("[O]nce we have identified accuracy as an independent requirement, it is much more difficult to give content to a fairness requirement.").

parties about the admissibility of TrueAllele. Courts should hold pre-trial evidentiary hearings to adequately assess the reliability and fairness of the new technology. In a state that uses the *Frye* standard, it is clear that one expert's opinion, or even several experts' opinions, may not satisfy the "general acceptance" standard.[273] As late as 2011, Dr. Perlin noted that the relevant scientific community developing the new computerized DNA technologies only consists of 50 to 100 people.[274] According to testimony in *Duffy* and *Shaw*, even this small community is divided regarding the verifiability of TrueAllele.[275] Given the small size of the scientific community able to verify the new technology and this lack of agreement, courts should give pause when assessing the verifiability of TrueAllele under the *Frye* standard.

While *Daubert* arguably created a more liberal admissibility standard than *Frye*,[276] *Daubert*'s fifth factor still requires courts weigh the "general acceptance" of the scientific technology in the relevant scientific community.[277] Given the difficult scientific nature of TrueAllele, judges may not serve as the best "gatekeepers" for this complicated technology.[278] As a result, judges may rely almost exclusively on the fifth *Daubert* factor;[279]

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273. *See supra* note 37 and accompanying text (noting that the relevant scientific community as a whole must accept the technique).

274. *See supra* note 196 and accompanying text (discussing Dr. Perlin's testimony in *Regina v. Colin Duffy & Brian Shivers*).

275. *See Duffy & Shivers Voir Dire Ruling*, *supra* note 186, at 12–13 (noting that the defense expert in *Duffy & Shivers* comes within the broader scientific community that has concerns about the TrueAllele technology); Order at 17, Ohio v. Shaw, CR-13-575691 (Oct. 10, 2014), http://www.cybgen.com/information/press-release/2014/TrueAllele-Casework-Ruled-Admissible-in-Ohio-Daubert-Challenge/admissibility.pdf (noting that the defense expert in *Shaw* testified that "the scientific community is unified in its opinion that there is no generally accepted means of attaching a statistical weight to low-template DNA where there is a possibility of allelic drop-out") (on file with the Washington and Lee Law Review).

276. *See supra* notes 67–71 and accompanying text (discussing the practical effects of *Daubert*).

277. *See supra* note 57 and accompanying text (listing *Daubert*'s use of *Frye*'s "general acceptance" test as its fifth factor).

278. *Cf. supra* notes 63–64 and accompanying text (describing the Ninth Circuit's begrudging response to the Supreme Court's requirement that courts now use the *Daubert* standard to analyze complicated technologies).

279. *See, e.g.*, *Duffy & Shivers Voir Dire Ruling*, *supra* note 186, at 16–17

however, courts should resist absconding their duty to independently investigate the TrueAllele technology and weigh the other four *Daubert* factors.

Ultimately, our legal system forces the prosecution to prove the "reliability" of their evidence in every case. The elusive definition of "reliability" gives courts wide discretion to balance accuracy and fairness how they see fit. Courts should thoroughly consider both the accuracy of the results and the fairness of the process and independently analyze emerging computerized DNA technologies.

(discussing one international court's almost exclusive reliance on the validation of the New York Commission on Forensic Science DNA Sub-Committee and the Committee's recommendation that New York should adopt TrueAllele).