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Beyond People v. Castro: A New Standard of Admissibility for DNA Fingerprinting

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BEYOND *PEOPLE V. CASTRO*: A NEW STANDARD OF ADMISSIBILITY FOR DNA FINGERPRINTING

Forensic science[1] employs a wide range of identification techniques[2] in an effort to link physical evidence to a particular individual. Forensic serologists[3] attempt to identify suspects from traces of blood, semen, saliva, or urine.[4] The most recent and potentially greatest contribution to forensic science is DNA typing.[5] The so-called "DNA fingerprint"[6] has evolved from the fields of molecular biology, chemistry, and population genetics,[7] and offers a new and potentially more precise way to establish the identity of

1. Forensic science in its broadest definition is the application of science to law. As our society has grown more complex it has become more dependant on rules of law to regulate the activities of its members. Forensic science offers the knowledge and technology of science to the definition and enforcement of such laws.

R. SAFERSTEIN, CRIMINALISTICS: AN INTRODUCTION TO FORENSIC SCIENCE 1 (1981).

2. The forensic scientist attempts to identify the origin of trace evidence left at the crime scene, including paint, fibers, hair, glass, soil, metals, and flammable and explosive residue. Stone, *Capabilities of Modern Forensic Laboratories*, 25 WM. & MARY L. REV. 659, 661 (1984). Other techniques include traditional fingerprinting and other, more exotic techniques, such as spectrographic examination (voiceprint). *See generally* P. GIANNELLI & E. IMWINKELRIED, SCIENTIFIC EVIDENCE (1986) [hereinafter GIANNELLI & IMWINKELRIED].

3. "Forensic serology consists of the identification and characterization of blood and other body fluids in the crime laboratory." FEDERAL BUREAU OF INVESTIGATION, HANDBOOK OF FORENSIC SCIENCE 30 (1984).

4. *Id.* at 31-32. Some genetic identification techniques include blood group (ABO) typing, human leukocyte antigen typing (HLA), neuron activation analysis (NAA), and gel electrophoresis. Thompson & Ford, *DNA Typing: Acceptance and Weight of the New Genetic Identification Tests*, 75 VA. L. REV. 45, 51 (1989) [hereinafter Thompson & Ford]. Each of these techniques is limited, although gel electrophoresis offers the greatest specificity through the typing of red blood cell enzymes and serum proteins. *Id.* For an overview of each of these techniques, see GIANNELLI & IMWINKELRIED, *supra* note 2, at § 7. The admissibility of gel electrophoresis has undergone a series of challenges and its future in the courts is uncertain. *See generally* Note, *The Admissibility of Electrophoretic Methods of Genetic Marker Bloodstain Typing Under the Frye Standard*, 11 OKLA. CITY U.L. REV. 773 (1986).

5. Practical use of DNA typing first came into existence in 1985 through the pioneering efforts of Dr. Alec Jeffreys of the University of Leicester in England. Comment, *DNA Identification Tests and the Courts*, 63 WASH. L. REV. 903, 908 n.22 (1988) [hereinafter *Identification Tests*]. The first reported use of the tests was in the Pitchfork double murder case in England. The story of Colin Pitchfork and the Narborough Village murders is the subject of a nonfiction account by J. WAMBAUGH, THE BLOODING (1989) [hereinafter J. WAMBAUGH].

6. The technique is also referred to as DNA typing, DNA profiling, and DNA print identification. Although at least one court has objected to the use of the term "DNA fingerprinting," *see infra* note 30, these terms will nevertheless be used interchangeably.

7. Thompson & Ford, *supra* note 4, at 56-57.

suspects.[8]

Since the advent of DNA typing, United States courts have addressed DNA identification evidence in both civil and criminal matters. In paternity suits, the technique is used widely and has quickly established itself as the preferred method for linking putative father to child.[9] DNA evidence has also been introduced, and almost always admitted, in scores of criminal cases.[10] However, while DNA technology has been heralded by prosecutors

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8. Among the more optimistic statements: "Other tests can exclude a man or suggest he's guilty. This one can positively nail him." Lewis, *DNA Fingerprints: Witness for the Prosecution*, DISCOVER, June 1988, at 47. High visibility cases, such as the disappearance of Melissa Brannen, a Fairfax, Virginia 5-year-old, prominently feature the DNA typing procedure. *See* Thomas & Davis, *Genetic Tests Awaited in Brannen*, Wash. Post, Dec. 19, 1989, at B1, col. 1.

In addition to its legal applications, reports have associated "DNA fingerprinting" with the tasks of tracking elephant poachers in Africa, *DNA Fingerprinting May Help Track Poachers*, U.P.I., Sept. 25, 1989 (NEXIS, Wires file), studying the breeding pattern of the purple martin, Okie, *Genetics: Clues to Birds' Behavior*, Wash. Post, Sept. 14, 1989, at A2, col. 4, proving Indian alienage in England, *Campaign to Unite Indian Families*, Daily Tel., May 10, 1989, at 4; *see also* Jeffreys, Brookfield & Semeonoff, *Positive Identification of an Immigration Test-Case Using Human DNA Fingerprints*, 317 NATURE 818, 818-19 (1985), and is said to be valuable in breeding condors. Phillips, *DNA Fingerprints*, L.A. Times, Nov. 14, 1988, § 2, at 3, col. 1 (home ed.). Physicians and hospitals may offer the new technology to replace baby bracelets, footprinting, and fingerprinting as a method for infant identification.

> Healthcare professionals have realized the need for accurate identification as a form of protection in the event of a major catastrophe, or individual disappearance. This procedure offers accurate identification through the most scientifically advanced, up to date technology. LIFEBANK offers the peace of mind of providing DNA comparison upon your request. For only pennies a day, the LIFEBANK services provide the security should a catastrophic event, or disappearance occur.

Advertisement for Lifebank, Inc., CHILD, Mar. 1990, at 130.

9. *See generally* Kaye, *DNA Paternity Probabilities*, 24 FAM. L.Q. 279 (1990) (discussing issues in DNA paternity testing). A report from one laboratory, Cellmark Diagnostics of Germantown, Maryland, which performs testing for both criminal and civil proceedings, claims that within a 14 month period it performed over 2000 tests for paternity cases, not one of which went to trial. Anderson, *DNA Evidence Questioned*, A.B.A. J., Oct. 1989, at 18, 19. Perhaps Cellmark's most highly visible paternity test was that involving the Mayor of Detroit, Coleman Young. *See Test Points to Detroit Mayor As Boy's Dad*, Chi. Tribune, May 13, 1989, at 4, col. 3.

10. According to a recent study, as of January 1990, forensic DNA evidence had been introduced in at least 185 cases by 38 states and the U.S. military. U.S. CONGRESS, OFFICE OF TECHNOLOGY ASSESSMENT, GENETIC WITNESS: FORENSIC USES OF DNA TESTS 14 (OTA-BA-438 July 1990) [hereinafter GENETIC WITNESS]. The Office of Technology Assessment study includes an appendix summarizing each of these cases. *Id.* at 157-72.

Lifecodes Corporation (Lifecodes) reports that its DNA test, "DNA-Print," has been admitted in 95 criminal cases in the United States. In all but two cases, Lifecodes was asked to testify for the prosecution. In only one case, People v. Castro, 144 Misc. 2d 956, 545 N.Y.S.2d 985 (Sup. Ct. 1989), has the Lifecodes evidence been held inadmissible to link the defendant to the crime scene. In another case, Caldwell v. State, 260 Ga. 278, 393 S.E.2d 436 (1990), part of the Lifecodes test, relating to its calculation of statistical probabilities, was excluded. Lifecodes has run approximately 5,000 such tests. Telephone interview with Karen Wexler, Public Relations Associate of Lifecodes (Jan. 17, 1990) [hereinafter Wexler interview].

as a "powerful tool to help solve violent crimes,"[11] its place in the criminal justice system is not yet assured.[12] Commentators have noted repeatedly that the sophistication of the technique and the attendant difficulty in judging its reliability present a unique challenge to the courts.[13] Despite concerns with the technique's reliability, no criminal or civil court, until recently, has held the evidence inadmissible to prove identity.[14]

Cellmark Diagnostics (Cellmark) reports that it has been called to testify regarding its DNA Fingerprint test in 55 criminal proceedings in 21 states. In all but one case, State v. Schwartz, 447 N.W.2d 422, 428 (Minn. 1989), the evidence was admitted. In State v. Pennell, 584 A.2d 513, 519 (Del. Super. Ct. 1989) and Commonwealth v. Curnin, 409 Mass. 218, —, 565 N.E.2d 440, 445 (1991), Cellmark's statistical data was excluded. Since the laboratory began operations in 1987, it has performed thousands of tests for criminal hearings. Telephone interview with Mark D. Stolorow, Manager, Forensic Science, Cellmark Diagnostics (Jan. 17, 1990) [hereinafter Stolorow interview].

Forensic Science Associates (F.S.A.) amplityped 200 forensic DNA samples in 1988. The amplitype test has been admitted in several cases in the United States, including Spencer v. Commonwealth, 240 Va. 78, 98, 393 S.E.2d 609, 621, *cert. denied*, 111 S. Ct. 281 (1990). In California v. Martinez, No. A 709321 (Super. Ct. L.A. County 1988), the test results were held inadmissible for failing to be generally accepted in the field of forensic science. Telephone interview with Jennifer Mihalovich of F.S.A. (Jan. 17, 1990) [hereinafter Mihalovich interview]; *see also* Levy, *DNA Evidence in Criminal Cases: Legal Developments*, N.Y.L.J., Apr. 25, 1990, at 1.

The F.B.I.'s DNA fingerprinting test was recently examined and admitted in United States v. Jakobetz, 747 F. Supp. 250 (D. Vt. 1990).

The disparity between the number of samples typed and the number of cases where the prosecution has introduced the evidence can be explained by a number of scenarios. First, the test results may yield no result, known as a "noncall." Wexler interview, *supra*. For example, a noncall may result when the DNA is of insufficient molecular weight to perform the experiment accurately or where the DNA is too degraded to produce a result. Second, the test may result in an exclusion when the DNA typing reveals that the suspect's DNA is of a different origin than that of the unknown or victim's sample. Lifecodes records an exclusion rate of 25%. *Id.* Third, the test results may not be introduced as a result of plea agreements. Faced with the test results, the suspect may admit guilt, obviating the need for a proceeding to determine the admissibility of the particular DNA evidence.

11. Hicks, *DNA Tests Proves Itself in Solving Crimes*, N.Y. Times, Feb. 21, 1990, at A24, col. 4 (letter to the Editor). John W. Hicks is the Assistant Director of the Laboratory Division at the Federal Bureau of Investigation. Hicks's letter was written in response to an earlier article, Kolate, *Some Scientists Doubt the Value of "Genetic Fingerprint" Evidence*, N.Y. Times, Jan. 29, 1990, at A1, col. 1.

12. *See* Baird, Neufeld & Scheck, *DNA Testing: Is Forensic DNA Testing Reliable?*, A.B.A. J., Sept. 1990, at 34; Note, *The Dark Side of DNA Profiling: Unreliable Scientific Evidence Meets the Criminal Defendant*, 42 STAN. L. REV. 465 (1990) [hereinafter *The Dark Side*]; Thompson, *Case Not Yet Closed on Forensic Use of DNA*, Wash. Post, Feb. 13, 1991, at A3, col. 1.

13. *See, e.g.*, Comment, *DNA Printing: The Unexamined "Witness" in Criminal Trials*, 77 CALIF. L. REV. 665, 670-76 (1989) [hereinafter *The Unexamined Witness*]; *The Dark Side*, *supra* note 12, at 495-526.

14. For cases where DNA evidence was excluded or limited, see generally United States v. Two Bulls, 918 F.2d 56 (8th Cir. 1990) (excluded); State v. Pennell, 584 A.2d 513 (Del. Super. Ct. 1989) (limited); Caldwell v. State, 260 Ga. 278, 393 S.E.2d 436 (1990) (same); Common-

The first serious confrontation between the proponents and skeptics of DNA typing occurred in *People v. Castro*.[15] *Castro* involved a long and unusual preliminary hearing in which the Supreme Court of Bronx County, New York, held that a particular set of DNA identification tests, ordered by the prosecution in an effort to link the defendant with the crime scene, were inadmissible as a matter of law.[16]

This Comment examines *Castro* and its potential effects on both future litigation and legislative action. In Part I, this Comment addresses the admissibility issues associated with DNA evidence. To facilitate discussion of these issues, Part II explains the science of DNA fingerprinting. Part III provides a detailed explanation of the *Castro* case, focusing on specific laboratory procedures assailed by the court. Part IV discusses the *Castro* court's three-pronged recommendation for future preliminary hearings on DNA evidence. In Part V, this Comment explores the legislative response to the technology in light of *Castro*. Part VI demonstrates the need to create standards governing DNA fingerprinting procedures. Finally, this Comment concludes that *Castro*—in holding the prior standard developed in *Frye v. United States*[17] poorly suited to the complexities of the DNA procedure—offers a sound analytical approach to all courts considering the introduction of forensic DNA evidence.

I. ADMISSIBILITY OF NOVEL SCIENTIFIC TECHNIQUES

Like all evidence produced through novel scientific techniques, DNA evidence must satisfy preliminary considerations of admissibility.[18] Courts use

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wealth v. Curnin, 409 Mass. 218, 565 N.E.2d 440 (1991) (reversing admission of DNA evidence and remanding for determination on general acceptance of statistical data); State v. Schwartz, 447 N.W.2d 422 (Minn. 1989) (excluded); People v. Castro, 144 Misc. 2d 956, 545 N.Y.S.2d 985 (Sup. Ct. 1989) (same). For cases where the evidence was admitted, see generally United States v. Jakobetz, 747 F. Supp. 250 (D. Vt. 1990); Andrews v. State, 533 So. 2d 841 (Fla. Dist. Ct. App. 1988), *review denied*, 542 So. 2d 1332 (Fla. 1989); Cobey v. State, 80 Md. App. 31, 559 A.2d 391 (1989); People v. Wesley, 140 Misc. 2d 306, 533 N.Y.S.2d 643 (Sup. Ct. 1988), *aff'd sub nom.* People v. Bailey, 156 A.D.2d 846, 549 N.Y.S.2d 846 (N.Y. App. Div. 1989), *appeal denied*, 75 N.Y.2d 810, 551 N.E.2d 1238, 552 N.Y.S.2d 560 (N.Y. 1990); State v. Pennington, 327 N.C. 89, 393 S.E.2d 847 (1990); State v. Ford, — S.C. —, 392 S.E.2d 781 (1990); Kelly v. State, 792 S.W.2d 579 (Tex. Ct. App. 1990); *Spencer v. Commonwealth* cases, discussed *infra* at note 162; State v. Woodall, 385 S.E.2d 253 (W. Va. 1989).

15. 144 Misc. 2d 956, 545 N.Y.S.2d 985 (Sup. Ct. 1989).

16. *Id.* at 977, 545 N.Y.S.2d at 998.

17. 293 F. 1013 (D.C. Cir. 1923). *Frye* held that to be admissible, a novel scientific technique "must be sufficiently established to have gained general acceptance in the particular field in which it belongs." *Id.* at 1014.

18. For an excellent treatment of the admissibility rules, see generally Giannelli, *The Admissibility of Novel Scientific Evidence: Frye v. United States a Half-Century Later*, 80 COLUM. L. REV. 1197 (1980).

two distinct approaches to determine the admissibility of novel scientific evidence.

The majority of jurisdictions has adopted the approach set forth in the 1923 case of *Frye v. United States*.[19] When considering the admissibility of any evidence produced through new scientific procedures, a *Frye* jurisdiction requires that the procedures gain "general acceptance" within the appropriate scientific community.[20] Attacks upon DNA typing usually focus on the "general acceptance" portion of the *Frye* test. However, because this technique finds its roots in molecular biology, chemistry, and population genetics, a court may have difficulty determining the appropriate scientific field before reaching the "general acceptance" question.[21]

Jurisdictions that do not adopt the *Frye* test apply a general "relevancy" test reflected in the Federal Rules of Evidence.[22] Under the federal rules, scientific evidence is treated as expert testimony; admissibility is conditioned on the qualification of the expert and the probative value of the evidence.[23] Specifically, when determining the admissibility of novel scientific techniques under the relevancy approach, Giannelli and Imwinkelried have suggested that courts apply a three-step analysis.[24] First, to assess the probative value of the evidence, courts must consider the reliability of the scientific evidence,[25] since probative value is concerned with assessing whether the proffered evidence has a tendency to make a fact of consequence "more probable or less probable than it would be without the evidence."[26] Next, the court should identify any "countervailing dangers" that may accompany introduction of the evidence.[27] Lastly, the court must weigh the probative value of the evidence against any identified dangers, excluding the evidence only

19. 293 F. 1013 (D.C. Cir. 1923).

20. *Frye*, 293 F. at 1014.

21. For a discussion of DNA typing and its admissibility under *Frye*, see Thompson & Ford, *supra* note 4, at 52-63. For a discussion of the acceptance of the technique under both *Frye* and the "relevancy" test, see *Identification Tests*, *supra* note 5, at 932-54; *The Unexamined Witness*, *supra* note 13, at 682-94.

22. Federal Rules 401, 402, and 702 seem to indicate that any relevant scientific evidence or testimony is admissible if it will assist the trier of fact and is not prejudicial, misleading, or overly time-consuming. However, neither the Federal Rules, nor their official commentaries, mention the *Frye* doctrine, leaving it unsettled whether the general acceptance standard had been replaced. Courts and legal scholars conflict on this issue.

The Unexamined Witness, *supra* note 13, at 686 n.101 (citation omitted); *see also* J. WEINSTEIN & M. BERGER, WEINSTEIN'S EVIDENCE 702-34 (1990).

23. FED. R. EVID. 702.

24. GIANNELLI & IMWINKELRIED, *supra* note 2, at § 1-6.

25. *Id.* at § 1-6(A).

26. FED. R. EVID. 401.

27. GIANNELLI & IMWINKELRIED, *supra* note 2, at § 1-6(B).

when its probative value is substantially outweighed by "unfair prejudice, confusion of issues, or [potential to] mislead[] the jury."[28]

It is possible to identify some countervailing dangers that courts, under both *Frye* and the federal rules, must address before submitting DNA evidence to the jury. Not only is any detailed explanation of scientific procedure apt to confuse a jury,[29] but also the popular designation of the

28. FED. R. EVID. 403. In the context of DNA identification, at least one court has found the *Frye* approach superior to that advanced by the federal rules. In State v. Schwartz, 447 N.W.2d 422 (Minn. 1989), attorneys for the state urged rejection of both *Frye* and State v. Mack, 292 N.W.2d 764 (Minn. 1980), the latter adding to *Frye* the requirement that experts in the field "generally agree that the evidence is reliable and trustworthy." *Schwartz*, 447 N.W.2d at 424. The State urged adoption of the federal rules' tests to consider the admissibility of DNA evidence in the murder trial of Thomas Robert Schwartz. After considering Minnesota Rules of Evidence 702, 703, 401, 402 & 403, which are substantially identical to their federal counterparts, the court declined:

> The state urges rejection of the *Frye* standard and adoption of an approach that would treat novel scientific evidence like other expert opinion evidence, admitting it if: a) it assists the trier of fact and there is a reasonable basis for it MINN. R. EVID. 702 and 703; b) it is relevant under rules 401 and 402; and c) the probative value is not outweighed by its potential for unfair prejudice, rule 403. To be admissible, relevant and reliable emerging scientific evidence need not necessarily have first passed muster within its appropriate scientific field, as required by *Frye*'s general acceptance prong. Without this safeguard, we believe an undesired element of subjectivity is possible in evidentiary rulings under the relevancy approach. The *Frye* standard, on the other hand, facilitates more objective and uniform rulings.

Schwartz, 447 N.W.2d at 424 (citations omitted).

In United States v. Jakobetz, 747 F. Supp. 250, 254 (D. Vt. 1990), the district court followed the relevancy test of United States v. Williams, 583 F.2d 1194 (2d Cir.), *cert. denied*, 439 U.S. 1117 (1978), which rejected *Frye*. Quoting *Williams*, 583 F.2d at 1198, the *Jakobetz* court reasoned that the relevancy test was better than *Frye*'s general acceptance standard:

> Unanimity of opinion in the scientific community, on virtually any scientific question, is extremely rare. Only slightly less rare is a strong majority. Doubtless, a technique unable to garner any support, or only minuscule support, within the scientific community would be found unreliable by a court. In testing for admissibility of particular type of scientific evidence, whatever the scientific 'voting' pattern may be, the courts cannot in any event surrender to scientists the responsibility for determining the reliability of that evidence.

Jakobetz, 747 F. Supp. at 254. The *Jakobetz* court articulated 14 factors to its relevancy test, *see* 747 F. Supp. at 254-55, and concluded that "[t]he essential question is not whether the technique is infallible, but rather whether the scientific technique exhibits 'a level of reliability sufficient to warrant its use in the courtroom.' " 747 F. Supp. at 255 (quoting *Williams*, 583 F.2d at 1198).

29. In a recent murder trial in Long Island, New York, DNA evidence was introduced by the prosecution to link the defendant to the murder scene. The prosecution called a laboratory technician, Lorah McNally of Lifecodes Corporation, to explain the technique to the jury. The testimony produced the following effect: "As Ms. McNally went through her testimony, dry, technical and frequently repetitive under cross-examination, some members of the jury seemed to have trouble paying attention. If they were not dozing, several did have their eyes closed." Lyall, *DNA Tests Link Golub To Killing, Expert Says*, N.Y. Times, Mar. 8, 1990, at B4, col. 4.

technique as "DNA fingerprinting" may confer an unwarranted connotation of the technique's accuracy.[30] Furthermore, the statistical frequency data[31] accompanying DNA evidence may increase the risk of unfair prejudice or confusion contemplated by the federal rules.[32] Although the impact of powerful frequency statistics on a particular court's balancing of probative value and prejudicial concerns remains unsettled, the distinctive character of this aspect of DNA fingerprinting presents a unique issue to the legal system; in the face of powerful statistical data, the threshold question of admissibility may be determinative of guilt.[33]

Whichever test is used, *Frye* or the relevancy test,[34] the admissibility of

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30. "[T]he word fingerprinting tends to suggest erroneously that DNA testing . . . will identify conclusively, like real fingerprinting, the one person in the world who could have left the identifying evidence at the crime scene." Commonwealth v. Curnin, 409 Mass. 218, —, 565 N.E.2d 440, 441 n.2 (1991).

31. In declaring a match between any given piece of typed trace evidence and the suspect, the DNA propounder will state that the chance of such a match occurring at random is statistically minute. *See, e.g., infra* text accompanying notes 70-72.

32. Rule 403 states: "Although relevant, evidence may be excluded if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury . . . ."

33. Because DNA evidence is so new and the resulting prejudice to the defendant is sufficiently great, it is imperative that the court satisfy itself that there exists a sufficient foundational basis as to the overall admissibility of the evidence. This must be done before the government exposes the jury to the lab results. If the court has explored only scientific acceptability and the reliability of acceptable testing procedures in camera, and then, at trial the government fails to show that the lab tests did conform to reliable procedures, the court would have to exclude the evidence for lack of foundation. In doing so, the resulting prejudice to the defendant would be obvious. Notwithstanding the fact that an objection is sustained and the evidence excluded, aside from valuable trial time wasted, the jury would be exposed to prejudicial proofs and left to speculate as to why the defendant opposed the ultimate result.

United States v. Two Bulls, 918 F.2d 56, 60 (8th Cir. 1990).

> [Until] [t]he judge has considered the admissibility of the results of the DNA testing during a pretrial hearing . . . a jury should not be given the evidence and allowed to determine the validity and soundness of the process because evidence of this character has too great a potential for affecting a jury's judgment.

Commonwealth v. Curnin, 409 Mass. 218, —, 565 N.E.2d 440, 442 n.7 (1991). "When an expert comes in and says there's a one in 700 million chance that your man is not the one—and you know he's one of only 30 million black men in the country—it just kills you. It intimidates the jury." Taylor, *From One Speck, A Case Is Made*, Nat'l L.J., Jan. 16, 1989, at 3, 22, col. 1. *But see* United States v. Jakobetz, 747 F. Supp. 250, 263 (D. Vt. 1990):

> The court does not believe that a jury will be awed into complete submission by DNA profile technology. To the extent a jury will be impressed, however, the [prosecution] has sufficiently established that the current reliability and accuracy of DNA profiling justifies an aura of amazement. That DNA profiling is a remarkable advancement in forensic science, however, does not preclude it from being presented to a jury.

34. *See generally* United States v. Two Bulls, 918 F.2d 56 (8th Cir. 1990) (finding *Frye*

DNA typing as a novel scientific technique will remain a contentious issue. Until there is a consensus among the courts and commentators that standards exist to safeguard against admission of unreliable test results, *Castro*'s questions on the reliability of individual laboratory procedures should continue to challenge the admissibility of the technique, ensuring that no DNA evidence is admitted prematurely.

II. THE TECHNIQUE FROM CRIME SCENE TO TEST RESULTS

The DNA typing procedure begins with forensic evidence. Blood stains, hair, skin tissue, and semen, or other bodily fluids may be recovered from the crime scene by common forensic procedures and then used to link a suspect to the crime.[35] After the biological matter is removed from the crime scene—for example, blood from stained clothing—the resulting "sample" is sent to a laboratory for DNA testing.[36] Currently, laboratories use

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and relevancy test compatible); United States v. Jakobetz, 747 F. Supp. 250 (D. Vt. 1990) (applying relevancy test); State v. Pennell, 584 A.2d 513 (Del. Super. Ct. 1989) (same); Andrews v. State, 533 So. 2d 841 (Fla. Dist. Ct. App. 1988) (applying relevancy test but stating that DNA evidence would still be admissible under *Frye*), *review denied*, 542 So. 2d 1332 (Fla. 1989); Caldwell v. State, 260 Ga. 278, 393 S.E.2d 436 (1990) (applying relevancy test); Cobey v. State, 80 Md. App. 31, 559 A.2d 391 (1989) (applying *Frye*); Commonwealth v. Curnin, 409 Mass. 218, 565 N.E.2d 440 (1991) (applying *Frye*); State v. Schwartz, 447 N.W.2d 422 (Minn. 1989) (applying modified *Frye*); People v. Castro, 144 Misc. 2d 956, 545 N.Y.S.2d 985 (Sup. Ct. 1989) (applying *Frye*); People v. Wesley, 140 Misc. 2d 306, 533 N.Y.S.2d 643 (Sup. Ct. 1988) (same), *aff'd sub nom.* People v. Bailey, 156 A.D.2d 846, 549 N.Y.S.2d 846 (N.Y. App. Div. 1989), *appeal denied*, 75 N.Y.2d 810, 551 N.E.2d 1238, 552 N.Y.S.2d 560 (N.Y. 1990); State v. Pennington, 327 N.C. 89, 393 S.E.2d 847 (1990) (applying modified *Frye*); State v. Ford, — S.C. —, 392 S.E.2d 781 (1990) (applying modified *Frye*); Kelly v. State, 792 S.W.2d 579 (Tex. Ct. App. 1990) (applying *Frye*); Spencer v. Commonwealth, 283 Va. 275, 384 S.E.2d 775 (applying relevancy test but stating that DNA evidence would still be admissible under *Frye*), *reaffirmed en banc*, 283 Va. 295, 384 S.E.2d 785 (1989), *cert. denied*, 110 S. Ct. 759 (1990); State v. Woodall, 385 S.E.2d 253 (W. Va. 1989) (applying *Frye*).

35. DNA tests may be performed only on sample cells that contain DNA. Mature red blood cells do not carry nucleic DNA. Likewise, urine and fecal matter are untestable because of the absence of DNA. White blood cells and other parts of the blood do, however, contain nucleic DNA. *See Identification Tests*, *supra* note 5, at 909 n.27.

While DNA typing could well revolutionize identification procedures, investigators may regard the technique as a mere gratuity. Police detectives must still generate, then narrow, a list of suspects, more-often-than-not the most taxing of all police functions. The Colin Pitchfork case stands as the rare exception. The police investigating the Pitchfork murders requested that all men in the surrounding geographic area between the ages of 13 and 30 submit blood samples for DNA testing in an attempt to identify the murderer of two local women. With the cooperation of the male population of an entire village, all but two men, of an estimated 5,500, submitted to the request. Colin Pitchfork was arrested after a friend admitted to submitting blood under Pitchfork's name. Note, *DNA Typing: A New Investigatory Tool*, 1989 DUKE L.J. 474, 474 [hereinafter *New Investigatory Tool*]. *See generally* J. WAMBAUGH, *supra* note 5.

36. At present, six organizations in the United States perform the DNA typing procedure. Of these organizations, five are private companies: Cellmark Diagnostics, 20271 Goldenrod

two different methods of DNA typing to analyze forensic samples.[37] Cellmark Diagnostics, Lifecodes Corporation, and the Federal Bureau of Investigation use restriction fragment length polymorphism analysis (RFLP). RFLP was used in *Castro* and therefore it is described in some detail below. The second approach is reflected in tests performed by Forensic Science Associates, using a product of Cetus Corporation. The Cetus test involves a technique known as "amplityping" and is discussed briefly below.[38]

A. DNA Typing and Restriction Fragment Length Polymorphism (RFLP)

1. Background: DNA and Polymorphic Sites

The human body is comprised of cells. Each cell is made up of forty-six chromosomes, twenty-three inherited from the subject's mother and twenty-three from the father.[39] Chromosomes are comprised of material called deoxyribonucleic acid (DNA), which is a chemical structure containing four building blocks known as bases or nucleotides.[40] Scientists refer to these bases by their initial letters A (adenine), G (guanine), C (cytosine), and T (thymine).[41] The order of these bases, throughout the DNA chain, ultimately determines the individual characteristics of every person. Except for identical twins, each person's DNA is unique and does not vary from cell to cell. Likewise, in the absence of a rare mutation, a person's DNA is immu-

Lane, Germantown, Maryland 20874, (301) 428-4980 & 1-800-USA-LABS; Lifecodes Corp., Saw Mill River Road, Valhalla, New York 10595, (914) 784-2600 & 1-800-LIFECOD; Forensic Science Associates (using a product of the Cetus Corporation), 3053 Research Drive, Richmond, California 94806, (415) 222-8883; Genescreen Inc., 2600 Stemmons Freeway, Suite 133, Dallas, Texas 75207, (214) 631-8152 & 1-800-362-8378; and Gennan Corp., 475 North Howard Street, Room 475, Akron, Ohio 44310, (216) 535-3200 & 1-800-262-9191. The sixth organization is the Federal Bureau of Investigation, Forensic Science Research and Training Center, Quantico, Virginia 22135, (703) 640-6131.

37. Forensic DNA typing is broken into two different approaches: RFLP analysis and the Cetus technique. Significant distinctions do, however, exist within any laboratory practice of RFLP. *See* Thompson & Ford, *supra* note 4, at 48-49. The criticism of Lifecodes' form of RFLP analysis may be imputed to some extent to other labs using a similar procedure. This cannot be said of the Cetus technique, which—while it has its own limitations—is manifestly different from RFLP. The repercussions of *Castro*, however, may erroneously cast suspicions on all DNA identification techniques. This is the fear of Forensic Science Associates, the only lab to employ the Cetus product. Mihalovich interview, *supra* note 10.

38. This Comment focuses on the RFLP analysis, *infra* at text accompanying notes 51-72, but outlines the Cetus technique to demonstrate the dissimilarity of the two DNA procedures. *See infra* text accompanying notes 73-80. The distinction is required to avoid an aggregate treatment of DNA fingerprinting because the procedures differ significantly. Moreover, the judicial acceptance of one technique does not obviate the need for a court or legislature to scrutinize the other. *See infra* note 177 and accompanying text.

39. J. KIRBY, DNA FINGERPRINTING 8 (1990).

40. *Id.*

41. *Id.*; *Identification Tests*, *supra* note 5, at 909-10.

table. Thus, a cell recovered from one part of a person will contain a DNA structure identical to that found in any other part of the same body, but different from any DNA structure found in somebody else.[42] The structure of DNA is most frequently referred to as a "double helix," best imagined as a long ladder twisted along its vertical axis.[43] The rungs of the ladder describe bonds between bases. According to the "base-pair rule," each base will bond only with its complement.[44] Therefore, an A base will only bond with a T base and a C base will only bond with a G base. A person's "genetic code" is determined by the sequencing of these base-pairs along the DNA ladder. The code carries the information required for production of the many proteins that make up the human body.

A portion of DNA that determines hereditary traits is called a gene.[45] Each gene is located at a specific site, or locus, upon a specific chromosome. Most sections (ninety-nine percent) of the DNA ladder are nonpolymorphic, meaning that they vary little from one individual to another.[46] There are, however, certain loci that vary significantly from person to person. These sites are called polymorphic, and contain the small variations in the order of the bases that are responsible for the differences in individual human beings.[47] All genes may have two or more different versions called alleles.[48] On polymorphic genes, these sites allow the individual to be recognized through DNA typing; by examining sites for a certain polymorphic sequence, scientists can discriminate between two persons' DNA.[49] The likelihood that two individuals share identical polymorphic genes is extremely rare and can be estimated through population genetics.[50]

2. *Restriction Fragment Length Polymorphism (RFLP)*

To begin the RFLP procedure,[51] technicians extract DNA from the foren-

42. J. KIRBY, *supra* note 39, at 1.

43. *Id.* at 9.

44. Thompson & Ford, *supra* note 4, at 62.

45. J. WATSON, N. HOPKINS, J. ROBERTS, J. STEITZ & A. WEINER, MOLECULAR BIOLOGY OF THE GENE 9 (4th ed. 1987) [hereinafter MOLECULAR BIOLOGY OF THE GENE].

46. For example, a nonpolymorphic site may consist of the DNA sequence for eyes, hands, the head, or other characteristics shared by all Homo sapiens. Thompson & Ford, *supra* note 4, at 62 n.79.

47. For example, the genes responsible for producing the proteins and antigens in blood are polymorphic, hence, the existence of different blood types. J. KIRBY, *supra* note 39, at 25.

48. MOLECULAR BIOLOGY OF THE GENE, *supra* note 45, at 12.

49. J. KIRBY, *supra* note 39, at 26.

50. *Id.* at 149.

51. For a detailed overview of the RFLP process, see Thompson & Ford, *supra* note 4, at 64-76; *see also* GIANNELLI & IMWINKELRIED, *supra* note 2, at 94-97 (Supp. 1990); Burk, *DNA Fingerprinting: Possibilities and Pitfalls of a New Technique*, 28 JURIMETRICS J. 455, 458-63 (1988); Kelly, Rankin & Wink, *Method and Applications of DNA Fingerprinting: A Guide*

sic sample through treatment with chemicals and enzymes.[52] In order to identify the polymorphic regions, restriction enzymes are introduced into the DNA through a process known as "digestion" or "restriction digestion."[53] The restriction enzymes recognize certain base-pair sequences and cut the DNA at those points, called "restriction sites." The restriction enzymes will cut any two nonpolymorphic sequences at the same point, producing DNA fragments of identical length. If the restriction enzyme encounters a polymorphic sequence, because of the base-pair arrangement, the fragment produced by the cutting action of the enzyme will be of a different length. The resultant fragment, cut at the polymorphic sequence, is known as a "restriction fragment length polymorphism," or RFLP.[54]

The DNA fragments are then lined up according to length to allow measurement and comparison by a process called "gel electrophoresis."[55] The RFLP's are placed on one end of an agarose gel with a positively charged field on the other end. Because the DNA molecule carries a negative charge, the fragments are attracted to the positive charge and will move through the gel toward the opposite end. How far the fragments travel is a function of size. The larger fragments will become mired at the top end of the gel while the shorter RFLP's will progress further towards the positively charged low end. Once the process is complete, the gel is stained and photographed both to ensure that the emerged pattern is recorded[56] and to confirm that all the DNA has been removed from the gel when the DNA is transferred to a stable membrane.[57]

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for the Non-Scientist, 1987 CRIM. L. REV. 105, 105-08 (1987); *New Investigatory Tool*, *supra* note 35, at 477-80; *Identification Tests*, *supra* note 5, at 911-16. *See generally* J. KIRBY, *supra* note 39 (comprehensive and detailed examination of the science and issues of DNA fingerprinting). For a description of the process found within reported cases, see United States v. Jakobetz, 747 F. Supp. 250, 251-54 (D. Vt. 1990); Andrews v. State, 533 So. 2d 841, 847-48 (Fla. Dist. Ct. App. 1988), *review denied*, 542 So. 2d 1332 (Fla. 1989); Caldwell v. State, 260 Ga. 278, —, 343 S.E.2d 436, 437-41 (1990); Cobey v. State, 80 Md. App. 31, 36-43, 559 A.2d 391, 393-98 (1989); People v. Wesley, 140 Misc. 2d 306, 314-17, 533 N.Y.S.2d 643, 645-50 (Sup. Ct. 1988), *aff'd sub nom.* People v. Bailey, 156 A.D.2d 846, 549 N.Y.S.2d 846 (N.Y. App. Div. 1989), *appeal denied*, 75 N.Y.2d 810, 551 N.E.2d 1238, 552 N.Y.S.2d 560 (N.Y. 1990).

52. In order to type the sample, a sufficient quantity of DNA must be present on the specimen. Also, the suspect's DNA may need to be separated from other biological matter or contaminants contained in the sample. A clean DNA sample is the first hurdle for any successful DNA typing. *See* Thompson & Ford, *supra* note 4, at 65-67.

53. People v. Castro, 144 Misc. 2d 956, 965, 545 N.Y.S.2d 985, 990-91 (Sup. Ct. 1989).

54. While not at issue in *Castro*, the process and use of restriction enzymes is itself not an infallible technique. At least 37 possible problems may result from an abnormality in the procedure. Thompson & Ford, *supra* note 4, at 68 n.107.

55. *Castro*, 144 Misc. 2d at 966, 545 N.Y.S.2d at 991.

56. *Id.*

57. Thompson & Ford, *supra* note 4, at 71 n.120.

Before the DNA is transferred to the membrane for the purpose of preserving and identifying the RFLP's, the fragments are treated with denaturing chemicals which split the DNA ladder down the center. When split into two strands containing complementary base-pair sequences, the strands are permanently fixed on the membrane through a process known as "Southern blotting" or "Southern transfer."[58]

Technicians next subject the DNA, present on the membrane, to the process of "hybridization" in order to identify the polymorphic sites.[59] The membrane is placed into a solution containing a genetic probe or set of genetic probes.[60] The probes are treated with a radioactive substance which allows subsequent recordation by use of X-ray film. Each probe contains a specific polymorphic sequence that will seek out and attach to a single strand of complementary DNA at a specific locus, ignoring the greater number of nonpolymorphic sequences.[61] Thus, the radioactive probe effectively highlights the polymorphic sequence. The X-ray, recording the positions of the probes, is known as an "autoradiograph" or "autorad."[62] Polymorphic segments appear on an autorad as bands or dark lines.[63] The location of the band on the membrane indicates how far the RFLP traveled in the gel. The distance traveled, in turn, reflects the size of the polymorphic fragment. Technicians express fragment length using a measure called a kilobase or "kb," defined as the length of a DNA sequence of 1000 base-pair units.

Because the base-pair sequence within each probe is known, the length of the fragments uniquely identifies the sample, allowing comparison with other samples using the distinctive bands appearing on each autorad. In criminal cases, Cellmark and Lifecodes use a single locus probe designed to recognize a specific polymorphic sequence. The single locus probe will usu-

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58. Southern blotting is named after Dr. Edward H. Southern, who first reported the process in 1975. *Id.* at 71 n.119; Cobey v. State, 80 Md. App. 31, 39, 559 A.2d 391, 395 (1989).

59. People v. Castro, 144 Misc. 2d 956, 966-67, 545 N.Y.S.2d 985, 991-92 (Sup. Ct. 1989).

60. Introduction of more than one genetic probe into the membrane is referred to as cocktail hybridization. *See* 144 Misc. 2d at 974, 545 N.Y.S.2d at 996.

61. At this point, finding the key polymorphic segments among all the other DNA segments on the blot is like finding a needle in a haystack. One way to find the needle would be to spread out the hay and pass a magnet over it. Similarly, in RFLP analysis, the DNA is spread out by electrophoresis and a genetic probe acts as a "biological magnet." The probe will lock onto the key polymorphic segments, but will not lock onto all the other "hay" DNA in the sample.

Thompson & Ford, *supra* note 4, at 71 (footnote omitted).

62. *Castro*, 144 Misc. 2d at 967, 545 N.Y.S.2d at 992.

63. For each series of hybridizations, the autorad may show a number of bands. The presence of several bands on the autorad will appear as dark lines, irregularly spaced and separated from each other, against a light, neutral-colored background. The effect has been likened to the appearance of a UPC code found on most products in the local grocery store.

ally produce two characteristic bands.[64] To generate high probabilities, multiple probes are usually run on the same membrane, either separately[65] or together.[66]

When seeking to match the DNA of two individuals, the DNA of each individual is placed in one of two "lanes" which appear on the autorad, thus permitting side-by-side comparison. For example, DNA of a known origin, such as that taken from the victim, is run alongside DNA of an unknown origin (e.g., DNA recovered from the blood-stained shirt of the suspect). The separate lanes contain a number of bands that will be examined to see if the fragments highlighted by the probe are of the same length. If the position of the bands appears to indicate that the fragments are the same size, the bands are said to "co-migrate."[67] In order to declare a "match," that is, to declare that the bands represent similar polymorphic fragment lengths, the lab must make a detailed examination and interpretation of the autorad.

First, the laboratory will visually examine the autorad to determine if the bands in separate lanes co-migrate or line up. This initial "eye-balling" step appears to be standard procedure in the laboratories practicing RFLP.[68] Next, the autorad may be examined by a computer-digitizing instrument or a video/computer apparatus that measures the length of the separate bands in order to obtain a more precise objective measurement, ultimately providing the scientist with the necessary basis to verify that the two samples match.[69]

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64. The bands mark two different alleles, one inherited from the father and one from the mother. If the mother and father have the same blood type, and thus share identical alleles, the result will appear as a single band because the alleles overlap. Thompson & Ford, *supra* note 4, at 72 & n.125 and accompanying text. This overlapping condition is referred to as a homozygous match. *See* MOLECULAR BIOLOGY OF THE GENE, *supra* note 45, at 10. In contrast to the single locus probe, laboratories may also use a multi locus probe, which seeks out a greater number of polymorphic sites, producing approximately 15 interpretable bands. GIANNELLI & IMWINKELRIED, *supra* note 2, at § 17-8 (Supp. 1990). Use of multi locus probes requires a relatively large sample of DNA. *Id.* Since the resulting number of bands is greater than single locus RFLP, the autorads are somewhat harder to interpret. *Id.*

65. The membrane can be re-hybridized with another probe. After one probe has been run, the excess solution is chemically washed and the process repeated with the new probe. People v. Castro, 144 Misc. 2d 956, 967, 545 N.Y.S.2d 985, 991 (Sup. Ct. 1989).

66. *See supra* note 60.

67. *See Castro*, 144 Misc. 2d at 967, 545 N.Y.S.2d at 992.

68. Lifecodes' visual identification technique was criticized in *Castro*. *See infra* text accompanying notes 129-30. Lifecodes still employs the visual method as a first step, though it has computer-digitizing and video equipment. Wexler interview, *supra* note 10. Cellmark also uses both visual and computer-assisted techniques for sizing the bands. Stolorow interview, *supra* note 10.

69. Even the use of the computer-digitizing and video equipment presents problems. These objective measuring tools are often unable to identify the fragment length precisely, due to external variables that may cause a distorted reading of the bands. The computer and video

Once a match has been declared, the laboratory consults a population data bank to estimate the frequency with which the specific allele would occur at random within a particular sub-group of the population.[70] In some instances, laboratories have assigned samples a statistical probability of random occurrence at one in 700,000,000.[71] In these cases, the practical effect of admitting DNA evidence is to permit a reasonable jury to conclude that there is no chance a sample found at a crime scene belonged to someone other than the defendant.[72]

B. DNA Typing and "Amplityping"

Forensic Science Associates (F.S.A.) uses a DNA fingerprinting technique known as "amplityping," a product of Cetus Corporation. The difference between the Cetus procedure and RFLP is that the sample size required for the former need be only a fraction of that required for RFLP analysis.[73] The Cetus technique permits rapid amplification of the targeted sequence of DNA through a procedure known as polymerase chain reaction (PCR).[74] The PCR method amplifies a single strand of denatured DNA, thereby producing multiple copies of the original DNA sequence.[75] The major advan-

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equipment may also be unable to account for band "shifts"—variations in positions of bands within a single lane. Moreover, both mechanisms still require "operator intervention"—a technician running the digitizing instrument over the band or directing the video equipment—and therefore human error will never be completely eliminated until the technology advances. Wexler interview, *supra* note 10.

70. In order for the alleles to occur at random within a sub-group, and thus to declare accurately the statistical probability of the non-random nature of the match, two preconditions must be met. *Castro*, 144 Misc. 2d at 968, 545 N.Y.S.2d at 992. First, the occurrence of a given polymorphic allele must not be caused by linkage disequilibrium, thus assuring that the alleles were passed randomly to the subject. Thompson & Ford, *supra* note 4, at 85. Secondly, the relevant sub-group of the population must be in Hardy-Weinberg equilibrium. To ascertain whether the sub-group is in Hardy-Weinberg equilibrium, the scientist will consult a data base to ensure that the occurrence of the allele in the sub-group is random. The Hardy-Weinberg principle is valid only where there is random mating in the population and no inbreeding. State v. Caldwell, 260 Ga. 278, —, 393 S.E.2d 436, 443 n.6 (1990); *see also* J. KIRBY, *supra* note 39, at 149-77 (explaining probability and statistical analysis).

71. *See, e.g.*, Spencer v. Commonwealth, 238 Va. 295, 301, 384 S.E.2d 785, 790 (1989), *cert. denied*, 110 S. Ct. 759 (1990).

72. *Id.* at 315, 384 S.E.2d at 797.

73. GIANNELLI & IMWINKELRIED, *supra* note 2, at § 17-8 (Supp. 1990).

74. For a detailed examination of the PCR technique, see generally Marx, *Multiplying Genes by Leaps and Bounds*, 240 SCI. 1408 (1988); Higuchi, Von Beroldingen, Sensabaugh & Erlich, *DNA Typing from Single Hairs*, 332 NATURE 543 (1988). For a brief overview of the Cetus test, see GIANNELLI & IMWINKELRIED, *supra* note 2, at 97-101 (Supp. 1990) (illustrations included); Thompson & Ford, *supra* note 4, at 76-78. For an explanation of PCR analysis in a reported case, see Spencer v. Commonwealth, 240 Va. 78, 95-98, 393 S.E.2d 609, 620-21, *cert. denied*, 111 S. Ct. 281 (1990).

75. GIANNELLI & IMWINKELRIED, *supra* note 2, at § 17-8 (Supp. 1990). The sequence of

tage of the PCR technique is that it enables a laboratory to test samples that would be too small for RFLP. The Cetus test, however, is relatively susceptible to misidentification if the sample is cross-contaminated with the DNA from another individual;[76] the amplification involved in the Cetus method may amplify not only the targeted DNA sequence, but also any contamination that may exist on the sample. Another disadvantage of the Cetus procedure is that because of the relatively small sample size analyzed, the technique cannot generate the high probabilities of RFLP.[77]

Using the Cetus product, F.S.A. ran approximately two hundred DNA identification tests in 1988.[78] In a California case, the court found the new technique accepted in scientific fields, but not generally accepted in the specific field of forensic science.[79] The test's results have also reportedly been introduced in at least eight criminal cases, in Pennsylvania, Florida, Virginia, Texas, Kansas, and California.[80] The technique was admitted in all but one case. Recently, in one of the *Spencer v. Commonwealth* cases, the Supreme Court of Virginia upheld the admission of the PCR method.[81]

III. *PEOPLE V. CASTRO*

The court in *People v. Castro*[82] exposed RFLP analysis to intense judicial scrutiny. Prior to *Castro*, no reported case undertook a searching inquiry into the shortcomings of RFLP analysis. In *Castro*, the defendant, Joseph Castro, stood accused of two counts of murder in the second degree.[83] Investigators seized Castro's wristwatch and found, on the watch, a bloodstain that Castro claimed was his own.[84] The prosecution sent the watch to Lifecodes Corporation for RFLP analysis and later sought to introduce the results of the test at trial. The proffer of the Lifecodes report started, in the words of presiding Judge Gerald Sheindlin, "the most comprehensive and extensive legal examination of DNA forensic tests held to date in the United States."[85]

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the new DNA strands is dictated by the sequence of the original DNA sequence. Technicians can produce a million copies of the original DNA strand by repeating the PCR cycle approximately 20 times. *Id.*

76. Thompson & Ford, *supra* note 4, at 77.

77. GIANNELLI & IMWINKELRIED, *supra* note 2, at § 17-8 (Supp. 1990).

78. *Id.*

79. California v. Martinez, No. A70931 (Super. Ct. L.A. County 1988).

80. Mihalovich interview, *supra* note 10.

81. 240 Va. 78, 98, 393 S.E.2d 609, 621, *cert. denied*, 111 S. Ct. 281 (1990). For a discussion of the *Spencer* cases, see *infra* note 162.

82. 144 Misc. 2d 956, 545 N.Y.S.2d 985 (Sup. Ct. 1989).

83. *Castro*, 144 Misc. 2d at 957, 545 N.Y.S.2d at 985.

84. *Id.* at 956, 545 N.Y.S.2d at 985.

85. *Id.* Noting that the technique had not passed appellate scrutiny in New York, the

Applying the principles of *Frye* and those enunciated in the New York case of *People v. Middleton*,[86] the Supreme Court of Bronx County began a preliminary hearing that would take over twelve weeks, producing a transcript of over five thousand pages.[87] In the end, Judge Sheindlin held the evidence inadmissible to prove that the DNA in the watch's bloodstain matched the victim's (inclusion).[88] This ruling precluded the prosecution from arguing that the DNA test results linked Castro to the crime scene. However, after the court ruled that Lifecodes had failed to conduct the necessary and scientifically accepted tests to prove inclusion, the prosecution offered the Lifecodes report to refute Castro's claim that the blood on the wristwatch was his own (exclusion). The court allowed the DNA evidence to show exclusion,[89] noting that the methods for determining exclusion—less complex and more reliable than those used to show inclusion—were generally accepted in the scientific community.[90]

The *Castro* court employed a three-prong test to determine the admissibility of the DNA evidence.[91] The test allowed the court to exclude the tests for the purposes of inclusion, even though Judge Sheindlin stated that the theory and techniques behind DNA fingerprinting were generally accepted under *Frye*. The court concluded that, when properly performed, "DNA forensic identification tests to determine inclusions are reliable and meet the *Frye* standard of admissibility."[92]

Attorneys Barry Scheck and Peter Neufeld led the defense of Joseph Castro. While their efforts are best chronicled elsewhere,[93] Scheck, Neufeld and their lead expert, Dr. Eric Lander, were able to convince the court that the

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Castro court cited to the introduction of DNA evidence in two New York criminal cases. *Id.* at 959, 545 N.Y.S.2d at 986 (citations omitted).

86. 54 N.Y.2d 42, 429 N.E.2d 100, 444 N.Y.S.2d 581 (1981).

87. People v. Castro, 144 Misc. 2d 956, 957, 545 N.Y.S.2d 985, 986 (Sup. Ct. 1989).

88. *Id.* at 977, 545 N.Y.S.2d at 997.

89. *Id.* at 978, 545 N.Y.S.2d at 998.

90. *Id.* at 973, 545 N.Y.S.2d at 995. The *Castro* court, however, made clear that future criminal cases involving DNA evidence should involve a pre-trial hearing on the laboratory procedures used in a given test. *Id.* at 978, 545 N.Y.S.2d at 998-99. The court further concluded:

> [G]iven the complexity of the DNA multi-system identification tests and the powerful impact that they may have on a jury, passing muster under *Frye* alone is insufficient to place this type of evidence before a jury without a preliminary, critical examination of the actual testing procedures performed in a particular case.

Id. at 960, 545 N.Y.S.2d at 987 (citation omitted).

91. *See infra* text accompanying notes 144-49.

92. *Castro*, 144 Misc. 2d at 973, 545 N.Y.S.2d at 995.

93. *See* Parloff, *How Barry Scheck and Peter Neufeld Tripped Up The DNA Experts*, AM. LAW., Dec. 1989, at 50 [hereinafter Parloff].

tests should be limited in certain areas.[94] The defense attack in *Castro* spanned both the theoretical and procedural aspects of the Lifecodes test. The harshest criticism, and the most devastating from the court's point of view, centered on Lifecodes' laboratory techniques and protocol.[95] The defense brief filed in the *Castro* hearing was a step-by-step challenge to the Lifecodes methodology.[96] In the *Castro* opinion, Judge Sheindlin accepted many of the defense arguments, criticizing Lifecodes for, among other things, its use of contaminated probes, the absence of laboratory controls, and for the inconsistency between its method for declaring a match between the samples and declaring a measured match in the population data base.[97] Ultimately, these deficiencies led the court to exclude the tests for purposes of inclusion, despite general acceptance of the DNA typing process—in theory—under *Frye*.

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94. While the defense faulted Lifecodes on a wide range of its techniques, only those recognized by the *Castro* court are discussed herein. Given the demanding nature of the subject matter, the points of contention are expressed simply. Those wishing to delve further into the specifics of the arguments, and matters not discussed here, should refer to the parties' memoranda. *See* Memorandum in Opposition to the Introduction of DNA Evidence (submitted to the Supreme Court of the State of New York, Bronx County, by Barry C. Scheck, Esq. and Peter J. Neufeld, Esq. on behalf of Joseph Castro, defendant in People v. Castro), *reprinted in* DNA: Frye Meets Future Shock—Are Trials of the Blood Moot? (prepared by Barry C. Scheck for the ABA Criminal Justice, Family Law, Science & Technology Sections and the Young Lawyers Division, Aug. 5, 1989) [hereinafter Memorandum].

95. *See Castro*, 144 Misc. 2d at 974, 977, 545 N.Y.S.2d at 996, 997-98. Among the most unusual events that occurred in the *Castro* hearing was a disclaimer entered by the prosecution's experts near the end of the hearing. Disturbed by the evidence that had come to light during the course of the hearing, Dr. Lander met with prosecution experts, Dr. Richard Roberts and Carl Dobkin, to discuss the Lifecodes tests.

> Roberts, prosecutor [Risa] Sugarman's first witness at the hearing, had testified for the prosecution in a half-dozen other *Frye* hearings, most of them involving Lifecodes tests. Roberts was so upset to discover from Lander's report that the company did not follow its published matching rule that he proposed a mini-summit conference: a meeting of the experts who had testified in *Castro* to see whether, as scientists, they could come to some consensus. . . .
>
> The experts concluded in a written statement that the tests performed by Lifecodes in the Castro case "were not scientifically reliable enough to support the assertion that the samples . . . do or do not match."

Parloff, *supra* note 93, at 55, col. 3. Dr. Roberts also appeared in the *Spencer v. Commonwealth* cases, where he "testified unequivocally that there was no disagreement in the scientific community about the reliability of DNA print testing." Spencer v. Commonwealth, 238 Va. 563, 570, 385 S.E.2d 850, 854 (1989), *cert. denied*, 110 S. Ct. 1171 (1990); *see also infra* note 162. Lifecodes says that of "the two prosecution experts who did attend the meeting, one has since declared that he's sorry he ever signed the statement and the other stated that the evidence was clearly a match." New York v. Castro Summary (undated document prepared by Lifecodes Corporation) (available from Lifecodes Corp., Saw Mill Road, Valhalla, N.Y. 10595).

96. *See* Memorandum, *supra* note 94.

97. *Castro*, 144 Misc. 2d at 969-73, 545 N.Y.S.2d at 994-98.

A. Analysis and Use of Contaminated Probes

First, Scheck and Neufeld argued that Lifecodes failed to explain adequately the presence of a 6kb band found, on autorad 17, in the lane of the deceased but not in the watch band sample. In its formal report to the District Attorney on July 22, 1987,[98] Lifecodes made no reference to this band.[99] At the hearing, however, all of the prosecution experts admitted to seeing a band at 6kb.[100] Acknowledging the presence of the 6kb band, Lifecodes attempted to account for the band by re-hybridizing the membrane with other probes, in an effort to show that the band was non-human.[101] The re-hybridization produced conflicting results.[102] While the court concluded that, because of the conflicting autorads, autorad 17 was unreliable by itself, the jury was permitted to weigh its unreliability in conjunction with the results of two other re-hybridized autorads that did not indicate a band at 6kb.[103] The court, however, took a dim view of the reuse of at least one contaminated probe during the additional hybridization, making clear that Lifecodes' practice of reusing contaminated probes was "unscientific and unacceptable."[104]

B. Analysis of Degraded DNA from the Watch and Use of Nonpolymorphic Probes

Second, the defense argued that the DNA extracted from Castro's watch, because of the DNA's apparent degradation, could not be adequately ana-

98. *See* Memorandum, *supra* note 94, at 37.

99. *Id.* at 36-37. An unexplained band on any autorad will threaten the reliability of the test. Identifying whether the band is of human or non-human origin is essential because a band of non-human origin could indicate that the sample is contaminated, undermining (or possibly vitiating) the accuracy of the test results. *Id.* at 37.

100. *Id.* at 36.

101. *Castro*, 144 Misc. 2d at 974, 545 N.Y.S.2d at 996; *see also* Memorandum, *supra* note 94, at 37-38. The results of the four probes were recorded on autorads 7, 8, 9, and 10. *Castro*, 144 Misc. 2d at 974, 545 N.Y.S.2d at 996.

102. Autorad 9, for detecting rDNA, showed no band at 6kb. Memorandum, *supra* note 94, at 37. Autorad 10, for detecting bluescribe plasmid, produced a useless result because of either probe or control lane contamination. *Id.* at 974 n.10, 545 N.Y.S.2d at 996 n.10. Finally, autorads 2 and 4, utilizing nonsynthetic probes for D2S44 and D17S79, did not react with any locus at 6kb, indicating that the observed band at 6kb was not part of either loci identified by the D2S44 and D17S79 probes. *Id.* at 975, 545 N.Y.S.2d at 996. A third re-hybridization took place with a bacterial and bluescribe plasmid, yielding autorads 7 and 8, which did produce a band at 6kb. The results reflected in 7 and 8 suggested that the band observed at 6 kb was produced by a contaminant and was not human in origin. *Id.*

103. *Castro*, 144 Misc. 2d at 975, 545 N.Y.S.2d at 996.

104. *Id.* at 974, 545 N.Y.S.2d at 997. The probes used in producing autorads 2 and 4 were nonsynthetic. A nonsynthetic probe is subject to contamination and may bind to bacterial DNA present on the membrane as well as human DNA. *Id.* at 971, 545 N.Y.S.2d at 994; *see also* Lander, *DNA Fingerprinting On Trial*, 339 NATURE 501, 503 (1989) [hereinafter Lander].

lyzed. Degradation smears the DNA along the lane, producing a broad and blurry print and potentially obscuring bands higher on the autorad.[105] The probe for D2S44[106] showed a homozygous band at about 10.25kb in the lane of the deceased.[107] The watch lane revealed a single band at roughly the same spot. Thus, the sole band observed in the watch lane was declared a homozygous match, i.e., the two samples shared a homozygous condition at the D2S44 locus.

Recall that Castro claimed the blood was his own. Because of the degraded condition of the watch sample, Castro challenged the report's conclusion that the blood on his watch matched that of the deceased. Defense expert Dr. Eric Lander noted that the degradation would tend to obscure higher bands. As such, the presence of a second band, indicating that the sample was heterozygous, would go undetected.[108] If the degradation were severe, there would be no indication that alleles existed above 10.25kb, making it impossible to determine whether the watch sample was heterozygous at the D2S44 location.

Prosecution expert Dr. Michael Baird testified that it was possible to examine the extent of degradation by eye and that, in this case, there was "some indication that there is enough material present to be able to get a signal in the 12-15kb range."[109] Dr. Lander responded that technicians could more accurately assess the extent of degradation by using a more sensitive test, a nonpolymorphic probe to detect signals above 15kb.[110] If loci were detected above that range, it could render unreliable Lifecodes' assertion as to the homozygous condition of the watch sample. The court agreed

105. *See generally* Thompson & Ford, *supra* note 4, at 89 n.195, 93 & n.273 and accompanying text; Memorandum, *supra* note 94, at 33-34.

106. The name of a particular probe indicates the specific locus to which the probe will attach. The names represent the site of the locus on the genome designated by the Human Gene Matching Conference. *See* Caldwell v. State, 260 Ga. 278, —, 393 S.E.2d 436, 439 (1990). Thus, D2S44 indicates a particular site on the distal arm of the second chromosome.

107. Because people inherit one chromosome from each of their parents, alleles at a particular locus may be the same size. If a particular allele from each parent matches, this condition is called homozygous. When identifying a homozygous condition, the bands may overlap and therefore be difficult to distinguish. If, however, the condition is heterozygous, the bands would occur at different positions on the autorad because the fragments would be of different length and thus would travel differently across the gel. A true homozygous condition would indicate only one band which is actually two-overlapping bands. Telephone Interview with Mark D. Stolorow, Manger, Forensic Science, Cellmark Diagnostics (Feb. 18, 1991); *see also* J. KIRBY, *supra* note 39, at 8; MOLECULAR BIOLOGY OF THE GENE, *supra* note 45, at 10.

108. Lander, *supra* note 104, at 503.

109. *Id.*

110. *Id.*

that such a probe was needed[111] and suggested that in the case of D2S44, Lifecodes technicians could have used a nonpolymorphic probe to detect loci above 13kb.[112] The conflicting expert testimony on the matter, however, was sufficient to place the issue before the jury.[113]

Regarding the questions of contamination and degradation, the court noted that preventive techniques, such as disposal of contaminated probes and the use of nonpolymorphic probes for degraded samples, were scientifically accepted and should have been utilized to resolve the conflicting testimony.[114] These are only two of the recommendations the court advanced in an effort to solve the apparent procedural deficiencies in Lifecodes' practice.

C. Sex of the Watch Lane and the Need for Controls

The attorneys in *Castro* also questioned whether sufficient controls were present to ensure accurate determination of the sex origin of the watch sample. If the blood from the watch was of male origin, then, by exclusion, it could not have come from the female victim. Castro had claimed the blood was his own. To resolve the gender question, Lifecodes subsequently conducted an experiment to test the sex origin of the watch sample. Hybridization with a probe for DYZ1[115] revealed the blood to be of female origin. To determine whether hybridization occurs correctly, technicians normally pre-

111. Because the DNA on the watch was degraded, i.e. eaten by bacteria, some question arises whether the blood DNA on the watch revealed a true homozygous band or a heterozygous band which appears homozygous—because the upper band had degraded away. Utilization of a non-polymorphic probe is essential in answering this question.

Castro, 144 Misc. 2d at 975, 545 N.Y.S.2d at 996.

112. *Id.* at 971, 545 N.Y.S.2d at 994.

113. *Id.* at 975, 545 N.Y.S.2d at 996-97. Though the court does not mention it, Lander reported Lifecodes' attempts to explain the apparent degradation after the issuance of their final report:

> To rebut the problem with degradation above 10 kb, Lifecodes probed the Southern blot with the human *Alu* repeat sequence and determined that it showed hybridization up to 23 kb molecular mass marker. In my opinion, the experiment itself was meaningless (because the ability to detect a sequence repeated 300,000 times in the genome has no bearing on the ability to detect single-copy sequences), but it was unnecessary to explain this to the court. Defence [sic] attorney Peter Neufeld, by now a veteran reader of autoradiograms, noticed that someone had accidentally misread the size markers: the *Alu* hybridization actually extended only to the 9.8-kb marker.

Lander, *supra* note 104, at 504.

114. *See Castro*, 144 Misc. 2d at 996, 545 N.Y.S.2d at 975.

115. The DYZ1 locus is estimated to repeat about 2,000 times on the distal arm of the Y chromosome. Because the male sex chromosome (XY) contains the Y chromosome and the female sex chromosome (XX) does not, hybridization of a male sex chromosome with the probe for DYZ1 should reveal an intense band at 3.7kb. If the blood has a female origin, no band will appear. Lander, *supra* note 104, at 503.

pare a control lane with the blood of a known sex type. Lifecodes' one control lane, allegedly known to contain a sample of female origin, yielded the same pattern as the watch lane sample, thus indicating that both the blood on the watch and the blood in the Lifecodes control lane were of female origin.

The testimony of Dr. Baird and a Lifecodes technician, however, produced conflicting answers on the sexual origin of the blood in the control lane.[116] Dr. Lander testified that the experiment could not be reliably performed without the presence of two controls, one to show a positive (male), the other to show a negative (female). Apparently persuaded by Dr. Lander's testimony, the court refused to admit the test.[117]

D. Declaring a Match: Two Unexplained Bands in the Watch Lane

A third problem emerging from the Lifecodes' report was the declared match between the observable bands in the watch lane and the bands in the victim's lane.[118] The hybridization for locus DXYS14 produced five bands in the watch lane and only three bands in the victim's lane.[119] Three bands shown in both lanes appeared to match. Lifecodes' Dr. Baird testified that the two additional bands in the watch lane, designated "A" and "B," were of nonhuman origin.

The court explained the implications of the presence of the additional bands:

> The existence of bands A and B are of critical importance in determining whether the forensic DNA testing performed in this case demonstrates these bands to be human DNA or nonhuman DNA. If bands A and B were of human origin then one would have to conclude that the DNA in [the victim's lane] and the DNA in [the watch lane] came from different sources.[120]

Lifecodes reported that the extra bands were contaminants "of a non-human

116. *Id.* At one point in the hearing, Baird claimed the sample came from a female. Later, the Lifecodes technician who performed the hybridization claimed the blood came from a male scientist. Baird attempted to explain that the male scientist had an abnormal Y chromosome which would not produce the usual band. Finally, Baird claimed that the control sample had come from a female technician. In addition to contributing to the exclusion of this sex-determining experiment, the conflicting testimony "underscored the need for meticulous record-keeping in DNA forensics, which may not originally have been as clear." *Id.*

117. *Castro*, 144 Misc. 2d at 975, 545 N.Y.S.2d at 997. The court endorsed the more accurate procedure: "In the absence of both controls, it is difficult to determine whether the probe hybridized correctly. The failure to include both [the positive male, and negative female,] controls renders the experiment uninterpretable." *Id.*

118. *Id.* at 976, 545 N.Y.S.2d at 997.

119. *Id.*; Lander, *supra* note 104, at 502.

120. *Castro*, 144 Misc. 2d at 976, 545 N.Y.S.2d at 997.

origin that we have not been able to identify."[121] Their additional attempts to identify the two suspect bands as nonhuman were unsuccessful.[122] Because of these defects at the DXYS14 locus, the court held that the evidence was inconclusive and inadmissible as a matter of law to show a match between the victim's blood and the blood found on the watch.[123] The court further believed that additional experiments might have discounted the two additional bands as contaminants.[124]

E. Statistical Probabilities: Population Genetics and the Need for a Uniform Matching Rule

The *Castro* defense team also assailed Lifecodes' use of population genetics.[125] Although the court never reached the statistical frequency issue, Judge Sheindlin did characterize Lifecodes' statistical procedures as unacceptable.[126]

The power of DNA typing lies not only in its ability to match samples, but also in its ability to represent accurately the probability that a declared match will occur at random in a specific population group.[127] The

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121. Lander, *supra* note 104, at 502.

122. *Id.*

123. *Castro*, 144 Misc. 2d at 976-77, 545 N.Y.S.2d at 997-98. Experts for both parties agreed that the samples should have been re-hybridized to see if the two additional bands reappeared. This was not done and both sides conceded that absent such tests, the evidence of the three pairs of identical bands was inadmissible to declare a match. Even Dr. Howard Cooke of the Medical Research Council in Edinburgh, the scientist who invented the probe used to hybridize at DXYS14 and who provided the probe to Lifecodes, testified that the unexplained bands had to exclude Castro. Lander, *supra* note 104, at 502.

Dr. Lander offered some insight on why Lifecodes deemphasized the extra two bands in the watch lane:

> Lifecodes' discounting of the two non-matching bands in the watch lane suggests that its identification of bands may have been influenced by making direct comparisons between lanes containing different DNA samples, rather than by considering each lane in its own right. . . .
>
> The tendency to use lane-to-lane comparison to distinguish between [legitimate] bands and [false indicators] is perfectly natural; such comparison can be quite helpful in certain experiments. However, in my opinion, it is inappropriate in DNA fingerprinting analysis of unknown samples—as one runs the risk of discounting precisely those differences that would exonerate an innocent defendant. Forensic laboratories should be required to use objective criteria for identifying the bands in each lane, and to use experiments to rule out proposed artefacts.

Lander, *supra* note 104, at 502. The *Castro* court culled this criticism of the Lifecodes matching rule and proposed a standardized, objective procedure for declaring a match. *Castro*, 144 Misc. 2d at 978-79, 545 N.Y.S.2d at 999.

124. *Id.* at 980, 545 N.Y.S.2d at 999.

125. *See* Memorandum, *supra* note 94, at 35-43.

126. *Castro*, 144 Misc. 2d at 978, 545 N.Y.S.2d at 998.

127. *See supra* notes 70-72 and accompanying text.

probability of error in either of these aspects influences the ultimate reliability of the test's conclusions. In *Castro*, Lifecodes allowed a greater probability of error in the sample matchings than in the random population predictions, but focused on the accuracy of the latter, making the test results appear more reliable than they were.[128]

In order to ensure the accuracy of a declared match, a laboratory must employ a method to determine whether bands that are similarly situated in their respective lanes actually occur at the same position. In this case, to ascertain the band's precise position, Lifecodes visually examined the band's position and declared a match. The court found this method acceptable[129] only when technicians follow this estimate with an objective qualitative measurement to ensure accuracy.[130] Lifecodes' matching rules would declare a match between two measured fragments if the difference in positions fell within three standard deviations,[131] accounting for insignificant variations between lanes.

After declaring a match between the samples, the laboratory next estimates the probability of the match occurring at random in the population. To make this estimation, the laboratory relies on data demonstrating the frequency with which particular alleles occur in the select population group. However, in order to represent accurately the statistical probability of the match occurring at random, the laboratory must apply the same standard deviation rule used in the fragment measurement to calculations of observed frequency in the population data base.[132] In *Castro*, the standard deviation rule used to declare a match between two measured fragments was abandoned when the laboratory consulted the population data bank; Lifecodes used a stricter calculation for examining deviations in the population

128. *Castro*, 144 Misc. 2d at 977 n.13, 545 N.Y.S.2d at 998 n.15.

129. *Contra* Lander, *supra* note 104, at 502-03.

130. *Castro*, 144 Misc. 2d at 977, 545 N.Y.S.2d at 998. Lifecodes employs a computer-digitizing apparatus, considered to be extremely accurate, as an objective measuring tool. *Id.*; Lander, *supra* note 104, at 502.

131. Lifecodes' standard deviation (s.d.) is reported to be a difference in position corresponding to 0.6 of molecular weight. Based upon this observation, Lifecodes announced a matching rule: two fragments are said to match if their band positions differ by less than 3 s.d.'s. This same matching rule was prescribed by Lifecodes for the samples in *Castro*. Thus, if fragments appeared within the 3 s.d. range, they were considered indistinguishable, and their average size reported. Lander, *supra* note 104, at 502. In *Castro*, however, the results produced from Lifecodes' computer-digitizing showed that the bands observed for D2S44 and D17S79 differed in position greater than 3 s.d.'s, falling outside the declared rule, thus indicating a nonmatch. *Id.* To answer the seemingly self-contradictory result, Lifecodes stated that the objective, computer-digitized measurements were not used to pronounce a match. Rather, Lifecodes' decision was based solely upon a visual matching of the band positions. *Id.*

132. *Castro*, 144 Misc. 2d at 967-69, 545 N.Y.S.2d at 995.

group.[133] Dr. Lander explained the practical effect of this inconsistency: "[It would be] like catching a match with a 10-foot-wide butterfly net, but then attempting to prove the difficulty of the feat by showing how hard it is to catch matches with a 6-inch-wide butterfly net."[134] The *Castro* court labeled this particular Lifecodes practice "dubious"[135] and declared that had it admitted the underlying physical evidence to show a match, the statistical probabilities formulated by Lifecodes "would [nonetheless] have been precluded or substantially reduced."[136]

F. State of the Art: Recommended Laboratory Techniques

Much of the conflict in *Castro* revolved around the optimum techniques and protocol for a DNA testing laboratory. Except where Lifecodes was blatantly deficient in its testing procedures, placement of blame on Lifecodes for the inadmissibility of the *Castro* DNA evidence might be unfair; when the *Castro* tests were performed, the forensic RFLP technique was still in its infancy and no detailed standards existed. Further, the migration of prosecution experts to the defense side in *Castro* demonstrates that the scientific community, as a whole, was itself grappling with the need to formulate specific criteria to guarantee accurate test results. Faced with the lack of scientific consensus and Lifecodes' flawed methodology, the *Castro* court nevertheless drew specific conclusions about the quality controls needed to admit forensic DNA typing in subsequent Bronx County cases.[137]

To ensure that technicians correctly declare a match between two frag-

133. When calculating the probability of a random match in the data base, the range of acceptable results fell within 2/3 s.d.'s. Lander, *supra* note 104, at 504.

134. *Id.*

135. *Castro*, 144 Misc. 2d at 977 n.13, 545 N.Y.S.2d at 998 n.15.

136. *Id.* at 978, 545 N.Y.S.2d at 998. "[W]hatever standard of deviation that was used by Lifecodes, it is clear that Lifecodes failed to use the same measurement in calculating the frequency of the alleles in the population. As noted, this is scientifically unacceptable." *Id.* at 977 n.13, 545 N.Y.S.2d at 998 n.15.

137. *Id.* at 969, 545 N.Y.S.2d at 993-95. The court explained that the techniques, developed in research laboratories where the nature of the testing and the testing environment permit repeated experiments to ensure accuracy, must incorporate more exacting procedural requirements within their forensic applications:

> When scientists use Southern Blots for clinical or diagnostic purposes they use fresh or dried blood samples from a known source. Thus, if a particular experiment gives an uninterpretable result, the scientist need only obtain more blood from the patient and re-perform the experiment. In forensic cases, however, the sample—say a blood stain found at a crime scene, or a semen sample obtained from a rape victim—is limited. If the experiment goes awry, there is no way to redo it. Thus, for forensic purposes, there is only one bite of the apple. The forensic scientist must take special pains to be sure that proper controls were utilized to ensure that the experiment was performed correctly.

Id. at 969-70, 545 N.Y.S.2d at 993. The defense had urged that the transfer from clinical to

ments, the court suggested that technicians perform a mixing (combined sample) experiment to uncover and account for between-lane variations.[138] In addition, when a high concentration of DNA exists in one of the lanes, the court recommended that the laboratory perform a serial dilution to ensure uniform band intensity.[139] In order to recognize degradation of a sample and ensure the proper run-length in the lane, the court recommended the use of nonpolymorphic probes to identify a certain locus at a specific point in the lane; if hybridization with a nonpolymorphic probe shows a band at that region, no degradation has occurred to that point in the lane.[140] Non-synthetic probes, manufactured by growing human DNA in a bacterial environment, have the tendency to hybridize with bacteria as well as human DNA. To avoid this problem, the court favored the use of synthetic probes to ensure that hybridization produces only bands of human origin.[141]

Addressing the inconsistency of the gender origin reports for the control sample, the court preferred the use of both male and female controls to ensure accurate sex-typing.[142] Finally, the court decried the use of differing

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forensic testing should be accompanied by stricter laboratory procedures. *See* Memorandum, *supra* note 94, at 15.

138. *Castro*, 144 Misc. 2d at 970, 545 N.Y.S.2d at 994. In a mixing experiment, a 50:50 mixture of the two samples is placed in a third lane. A match should only be declared if the third lane produces the same pattern as the combined pattern of each sample separately. *Id.*; Lander, *supra* note 104, at 501. In forensics, however, it may not always be possible to run a mixing experiment. Because additional DNA is needed to create the third lane, the sample size must be of sufficient quantity to allow the mixture. *Id.* In *Castro*, the court recommended a mixing experiment whenever a sufficient amount of DNA is available, but offered no guidance where sample size would preclude the experiment. *Castro*, 144 Misc. 2d at 970, 545 N.Y.S.2d at 994. Paradoxically, both Lifecodes and Cellmark agree that a mixing experiment is generally not possible in forensic cases because the sample size is frequently too small. Wexler interview, *supra* note 10 (mixing experiments performed seldom to never); Stolorow interview, *supra* note 10 (mixing experiment rarely performed and not a panacea). Dr. Lander suggests that nonpolymorphic probes should be utilized "to verify that the lanes have run at equal speeds and to provide standards against which fragment sizes can be measured precisely." Lander, *supra* note 104, at 501.

139. *Castro*, 144 Misc. 2d at 971, 545 N.Y.S.2d at 994.

140. Observing the controversy surrounding D2S44, the court suggested that technicians could have utilized a nonpolymorphic probe to test for degradation above 10.25kb in the watch lane. *Id.* Karen Wexler of Lifecodes, however, admits that no probe existed for the 10-15kb range at the time the test was run in 1987. Wexler interview, *supra* note 10.

141. *Castro*, 144 Misc. 2d at 971, 545 N.Y.S.2d at 994.

142. *Id.* at 972, 545 N.Y.S.2d at 994. Lifecodes attributed the *Castro* mix-up to a failure of communication within the lab. Indeed, many of the procedures criticized have been improved since the *Castro* sample was analyzed. Karen Wexler reported that, when the sample was run in 1987, the laboratory was new, with scientists mixing their own probes and technicians contributing their own blood for use in the control lanes. The *Castro* sample was apparently accepted as a pro bono project of the laboratory, and scientists used the sample to perfect the testing procedures. The lab now uses a uniform DNA for the control lanes and has a separate development staff to produce the probes. In addition, standard practice at Lifecodes now in-

matching rules for RFLP's and the population data bank.[143]

IV. INADEQUACY OF FRYE: A MODEL FOR FUTURE HEARINGS

Examining the *Frye* standard and other New York principles of admissibility, the *Castro* court found the "generally accepted" requirement ill-suited to manage the highly complex procedures involved in DNA typing.[144] Instead, the court chose to apply a three-prong analysis to the evidence:

> 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?
>
> Prong III. Did the testing laboratory perform the accepted scientific techniques in analyzing the forensic samples in this particular case?[145]

The first two prongs represent the requirements of *Frye* for determining whether the technique sought to be introduced is considered generally acceptable in the scientific community.[146] The third prong reflects the court's own concern with *Frye*'s inadequacy.[147] The *Castro* court opined that, because the *Frye* test obscures critical problems that can arise in the application of a particular technique, "a different approach is required in this complex area of DNA identification. The focus of this [(*Frye*)] controversy must be shifted. It must be centered around the resolution of the third prong."[148]

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cludes extensive record keeping. Wexler interview, *supra* note 10. Cellmark does not type for gender and hence does not encounter the male/female control lane issue. Stolorow interview, *supra* note 10.

143. Lifecodes reported that a uniform matching rule is applied across the RFLP's and data bank. The stated rule is that the bands must appear within 2% of each other. Both Cellmark and Lifecodes employ the use of monomorphic probes, which identify a band at 4kb. The probe is run on each sample and permits the lab to account for uniform shifting between bands. Wexler interview, *supra* note 10. Though the deviation is measured, problems may exist in extrapolating the deviation to show the shift in all of the lanes. Stolorow interview, *supra* note 10.

144. "It has been observed that: 'Perhaps the most important flaw in the *Frye* test is that by focusing attention on the general acceptance issue, the test obscures critical problems in the use of a particular technique.' " *Castro*, 144 Misc. 2d at 960, 545 N.Y.S.2d at 987 (quoting Giannelli, *The Admissibility of Novel Scientific Evidence: Frye v. United States, a Half-Century Later*, 80 COLUM. L. REV. 1197, 1201 (1980)).

145. *Castro*, 144 Misc. 2d at 960, 545 N.Y.S.2d at 987.

146. *See* Frye v. United States, 293 F. 1013, 1014 (D.C. Cir. 1923).

147. *Castro*, 144 Misc. 2d at 960, 545 N.Y.S.2d at 987.

148. *Id.* (citations and quotations omitted).

If a court, in applying *Frye*, finds that the theory behind DNA fingerprinting (prong one) and the techniques themselves (prong two) are generally accepted, then resolution of the third prong, application of theory and technique to a particular set of tests, should command the case-by-case attention of the court. Because no accepted standards exist that would permit a court to dispense with the third prong, *Castro*'s recommendation for a preliminary hearing to determine admissibility offers a prudent way to determine whether a laboratory performed the tests under reliable laboratory conditions in a particular case. *Castro*'s three-prong approach was recently adopted by the Eighth Circuit in *United States v. Two Bulls*.[149]

While the *Castro* court ultimately concluded that DNA forensic identification evidence would be admissible under *Frye*,[150] it proposed a model for future pre-trial hearings in an effort to ensure the reliability of the future DNA evidence prior to admission.[151]

First, the court proposed that parties be required to give adequate notice of intent to offer DNA evidence if such intent exists.[152] This requirement would allow both parties sufficient time to mount a rebuttal case or to seek alternative testing.[153] Currently, some state legislatures have already im-

149. 918 F.2d 56, 60 (8th Cir. 1990).

> We fail to see how [the *Castro*] analysis is *sui generis* or that it in any way allows intrusion of the court into deciding problems of weight vis a vis admissibility. When the evidence is so prejudicial and the admissibility seriously challenged, trial courts routinely hear motions in limine preliminary to the offer at trial.

Id. "This approach [to DNA evidence], whether it be under [Federal Rule of Evidence] 702 or *Frye*, should require the court to satisfy itself that the evidence meets all three tests laid out in *Castro*." *Id.*

150. *Castro*, 144 Misc. 2d at 973, 545 N.Y.S.2d at 995.

151. A pre-trial hearing should be conducted to determine if the experiments and calculations performed by the testing laboratory in the particular case yielded results sufficiently reliable to be presented to the jury. This hearing will also serve to aid the trial Judge in formulating appropriate instructions to the jury in the event sharp issues of fact emerge from the hearing.

Id. at 978, 545 N.Y.S.2d at 998-99.

152. *Id.* at 978, 545 N.Y.S.2d at 999.

153. DNA typing has proved useful both to convict and to exculpate a suspect. One of the most notable exculpatory cases involved Gary Dotson, who was convicted and sentenced in 1979 for raping Cathleen Crowell Webb. Even while incarcerated Dotson maintained his innocence, and in 1985 Webb admitted Dotson was wrongfully charged. Pleas for a gubernatorial pardon were ineffective, although Illinois Governor James Thompson did commute his sentence to the six years Dotson had already served, subject to good behavior. However, Dotson's repeated parole violations sent him back to prison. Meanwhile, F.S.A. ran tests on Webb's underwear and concluded that the source of the semen found there was not Dotson. Dotson was granted a new trial and the state refused to prosecute. Moss, *Free at Last*, A.B.A. J., Oct. 1989, at 19. In a context similar to the Dotson case, the District of Columbia recently had the opportunity to consider its first case involving DNA evidence. Edward E. Green, defendant in a D.C. rape case, hoped to introduce purportedly exculpatory DNA test results.

posed a similar notice requirement on state prosecutors.[154]

Second, the court would mandate that the proponent of DNA evidence make available for discovery any books, quality control tests, sample reports, or written reports of lab procedure (including the lab's matching methods), as well as actual measurements and the standard deviation used.[155] The court would also require the propounder to produce a laboratory statement on the method used to calculate allele frequency in the population data bank, a copy of the data pool for each locus examined, and certification by the laboratory that the same matching rule was used for both the sample and population pool frequencies. In addition, the court proposed requiring a laboratory statement on the presence of contaminants, degradation, or other observed defects, and the steps taken to ensure noninterference with the results. Finally, the court would require the propounder to demonstrate the chain of custody for each sample.[156]

Compared with the notice requirement, the documentation requirements are certainly more onerous. The *Castro* court appeared to aggregate all the points of the defense challenge: it produced a strict discovery requirement that may ease the burden on subsequent DNA typing opponents[157] and required the proponent to bear the burden of establishing the proper performance of the tests and calculations. Once established, the burden of proof would shift to the opponent to establish by clear and convincing evidence that the test results should be suppressed or modified.[158]

If promulgated, uniform standards should find a place in *Castro*'s recommended three-prong preliminary hearing, a hearing which emphasizes not only the accepted nature of the proffered DNA typing theory and techniques, but also the reliability of a specific laboratory's testing procedures. As evidenced by the *Castro* holding, it will be increasingly difficult to chal-

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See Gellman, *Genetic Testing Casts Doubt on Rape Victim*, Wash. Post, Feb. 16, 1990, at D1, col. 3. Armed with the test results, Green moved for a new trial. The motion was unopposed and the United States Attorney's Office declined to re-prosecute the case. The court, therefore, never got a chance to consider the DNA evidence. Gellman, *DNA Test Clears Man Convicted of SE Rape; Move Keeps Findings out of D.C. Court*, Wash. Post, Mar. 20, 1990, at A12, col. 3.

154. *See, e.g.*, MD. CTS. & JUD. PROC. CODE ANN. § 10-915(c)(1) (1989) ("If the State decides to offer evidence of a DNA profile in any criminal proceeding, the State shall . . . , [a]t least 15 days before the criminal proceeding, notify in writing the defendant . . . and . . . make available . . . any report or statement to be introduced . . . .").

155. People v. Castro, 144 Misc. 2d 956, 979, 545 N.Y.S.2d 985, 999 (Sup. Ct. 1989).

156. *Id.*

157. Maryland has partially codified these prescriptions. MD. CTS. & JUD. PROC. CODE ANN. § 10-915(c)(1) (1989) (The State shall "make available . . . any report or statement to be introduced . . . and require the presence of any person in the chain of custody as a prosecution witness.").

158. *Castro*, 144 Misc. 2d at 979, 545 N.Y.S.2d at 999.

lenge the generally accepted nature of the theory and technique of RFLP. Thus, the third prong of the *Castro* model should command the attention of courts considering DNA evidence.[159] As the RFLP technique becomes more common and standards evolve, a proponent of DNA evidence will likely need only show conformity with these standards; this showing may then be sufficient to shift the burden to the opponent to prove that the results are unreliable.[160]

As a final matter, the *Castro* court declared that, in general, any issue of fact concerning the reliability of the test would go to the weight, not the admissibility, of the evidence. The results would only be inadmissible where the opponent could demonstrate that the specific tests performed were "so unreliable."[161] As to what constituted the requisite unreliability, the court offered only the test results in *Castro*.[162]

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159. Even if the reliability of a technique is established, the reliability of evidence derived from that technique will depend on whether the technique was properly applied on the particular occasion involved in the case. "Proper application" requires an examination into a number of factors: (1) if instrumentation is used in the technique, whether the instruments were in proper working order at the time the technique was employed; (2) whether the proper procedures were followed when the technique was administered; and (3) whether the person using the technique and the person interpreting the results were properly qualified.

GIANNELLI & IMWINKELRIED, *supra* note 2, at § 1-8.

160. As recently noted by the court in Commonwealth v. Curnin, 409 Mass. 218, 565 N.E.2d 440 (1991):

> In time, assuming one or more DNA testing processes come to be accepted, the only questions will be whether an accepted process was properly followed in a given case and perhaps the competence of the testing laboratory. At that point in the development of the testing system, a voir dire hearing may cease to be necessary, at least in certain cases.

Curnin, 409 Mass. at —, 565 N.E.2d at 442 n.7.

161. *Castro*, 144 Misc. 2d at 979, 545 N.Y.S.2d at 999.

162. By unveiling the inconsistencies and errors in Lifecodes' procedures, the *Castro* case may cast a shadow on the use of the Lifecodes test in other cases. In the Spencer v. Commonwealth cases, 238 Va. 275, 384 S.E.2d 775 (Tucker murder), *reaffirmed en banc*, 238 Va. 295, 384 S.E.2d 785 (1989), *cert. denied*, 110 S. Ct. 759 (1990) [hereinafter "*Spencer I*"]; 238 Va. 295, 384 S.E.2d 785 (1989) (Davis murder), *cert. denied*, 110 S. Ct. 1171 (1990) [hereinafter "*Spencer II*"]; and 238 Va. 563, 385 S.E.2d 850 (Hellams murder), *cert. denied*, 110 S. Ct. 1171 (1990) [hereinafter "*Spencer III*"], the Virginia Supreme Court upheld the use of Lifecodes' tests that featured the same polymorphic probes and experts as those assailed in *Castro*.

Timothy Wilson Spencer was convicted for the capital murder and rape of Susan Tucker, *Spencer I*, 238 Va. at 278, 384 S.E.2d at 776, the capital murder, rape, and burglary in the death of Debbie Davis, *Spencer II*, 238 Va. at 299, 384 S.E.2d at 788, and the capital murder, rape, sodomy, and burglary of Dr. Susan Hellams. *Spencer III*, 238 Va. at 565, 385 S.E.2d at 851. Spencer was sentenced to death in all three trials. In all three cases, semen collected from the crime scene was compared with a sample of Spencer's blood using DNA typing. *Spencer I*, 238 Va. at 280, 384 S.E.2d at 777 (Tucker); *Spencer II*, 238 Va. at 301, 384 S.E.2d at 790-91 (Davis); *Spencer III*, 238 Va. at 567-68, 385 S.E.2d at 853. Lifecodes declared a match and set the statistical probability at one in 135,000,000 for the Tucker sample, 238 Va. at 280, 384

V. LEGISLATIVE RESPONSE TO THE NEW TECHNOLOGY: THE STATE OF MARYLAND

As technology progresses and the number of DNA cases proliferates, state legislatures will undoubtedly address DNA typing. A number of states have already provided funding for DNA testing facilities and identification re-

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S.E.2d at 789, and one in 705,000,000 for both the Davis and Hellams samples, 238 Va. at 301, 384 S.E.2d at 790; 238 Va. at 568 n.2, 385 S.E.2d at 853 n.2.

In upholding the admission of the DNA evidence in each case, the Virginia Supreme Court found the test to be "a reliable scientific technique," 238 Va. at 290, 384 S.E.2d at 783; 238 Va. at 315, 384 S.E.2d at 797; 238 Va. at 573, 385 S.E.2d at 855-56, Virginia having recently rejected the *Frye* test in O'Dell v. Commonwealth, 234 Va. 672, 696, 364 S.E.2d 491, 504, *cert denied*, 109 S. Ct. 186 (1988). While the *Spencer* court flatly rejected the application of *Frye*, it noted that the RFLP procedure would have been accepted even if *Frye* had been applied. 238 Va. at 290 n.10, 384 S.E.2d at 783 n.10; 238 Va. at 315 n.11, 384 S.E.2d at 797 n.11; 238 Va. at 573 n.5, 385 S.E.2d at 856 n.5. Thus, the *Spencer* court may have indirectly added to the *Frye* equation; courts in *Frye*-governed jurisdictions might consult the *Spencer* court's dicta that "even if *Frye* were the test in Virginia, DNA printing would meet that test." *Id.*; *see* GIANNELLI & IMWINKELRIED, *supra* note 2, at § 1-5(c) (criticizing courts that use prior judicial decisions to determine whether *Frye*'s general acceptance has been achieved).

The court found both that the Lifecodes test was "properly conducted" and the evidence was "undisputed." 238 Va. at 290, 384 S.E.2d at 783; 238 Va. at 315, 384 S.E.2d at 797; 238 Va. at 573, 385 S.E.2d at 855. The defense produced no expert testimony to rebut the prosecution's case. *Id.* In *Spencer III*, however, the defense objected to Dr. Richard J. Roberts' testimony "that there was no disagreement in the scientific community about the reliability of DNA print testing." 238 Va. at 510, 385 S.E.2d at 854. Spencer contended that the trial court erroneously limited his cross-examination of Roberts on this claim. But because Spencer did not provide the questions he wanted to ask Dr. Roberts, the issue was not preserved for appeal. *Id.* Although it is unclear what a full cross-examination may have uncovered, the lower court's decision appears ominous because the same Dr. Roberts would publicly distance himself from one of Lifecodes' procedures in the *Castro* case, calling it scientifically unreliable. *See supra* note 95. The Virginia Supreme Court, perhaps erroneously, mistook Spencer's inability to challenge the test generally as an admission of the test's infallibility in the case at bar: "Indeed, Spencer acknowledges that the evidence establishes that the DNA tests are accepted 'as reliable within the scientific community' and that he 'was unable to find or produce one qualified expert to debunk whether the theory of DNA printing or the statistic generated therefrom.' " *Spencer I*, 238 Va. at 289, 384 S.E.2d at 783.

Thus, the challenge found in *Castro* was conspicuously absent in the Virginia pronouncement. Presumably, subsequent introduction of DNA evidence in Virginia will only be susceptible to attack on the weight given to any particular test. This will be true not only for the RFLP method, but also for the PCR, which was accepted by the Virginia Supreme Court in *Spencer IV*. *See* Spencer v. Commonwealth, 240 Va. 78, 98, 393 S.E.2d 609, 621, *cert. denied*, 111 S. Ct. 281 (1990). Without passing judgment on these results, *Spencer I*, *Spencer II*, and *Spencer III* should be examined in light of *Castro*, especially since the same procedures, probes, and experts were involved in each case. *See generally* Comment, *Spencer v. Commonwealth and Recent Developments in the Admissibility of DNA Fingerprint Evidence*, 76 VA. L. REV. 853 (1990) (exploring the *Spencer* cases and DNA issues).

Drawing parallels between the specifics of the *Castro* and *Spencer* cases is impossible; because the quality of procedures may differ with the handling of each sample and the results may differ with variables such as sample size, any defect in *Castro* cannot be imputed automatically to the *Spencer* test.

search.[163] In addition, some states have prescribed the use of DNA identification for paternity disputes.[164] Still other legislatures have established DNA data banks to track known criminal offenders.[165] While these data banks operate like traditional fingerprint files, cataloguing DNA and its wealth of genetic information raises serious privacy concerns that courts and legislatures will be required to address.[166]

Louisiana,[167] Minnesota,[168] and Maryland[169] have enacted statutes specif-

163. *E.g.*, 1988 Conn. Acts 77 (Reg. Sess.) (providing funding not to exceed $2.5 million to develop a system of DNA identification for all law enforcement agencies); 1989 Iowa Legis. Serv. 780 (West) (providing funding for DNA profiling equipment and staff); WASH. REV. CODE § 43.43.752 (Supp. 1990) (charging the state patrol, in consultation with the University of Washington school of medicine, with the development of a DNA identification system).

164. *E.g.*, ARK. STAT. ANN. § 9-19-108 (Supp. 1989) (DNA testing allowed in paternity cases to establish identity of putative father); LA. CIV. CODE ANN. art. 187 (West Supp. 1990) (same); MONT. CODE ANN. § 40-5-201 (1989) (same); N.M. STAT. ANN. §§ 40-11-12 to -11-13 (1989) (same).

165. *E.g.*, CAL. PENAL CODE § 290.2 (West Supp. 1990) (blood specimen of sex crime offender to undergo DNA analysis); FLA. STAT. § 943.325 (Supp. 1990) (DNA specimen required for specific criminal offenses); IOWA CODE § 13.10 (Supp. 1989) (DNA specimen as condition of release for all felons and indicted misdemeanants); MINN. STAT. § 609.3461 (Supp. 1990) (must obtain and preserve DNA specimen for certain criminal and juvenile offenders); WASH. REV. CODE § 43.43.754 (1989) (DNA specimen for felons and violent criminals).

166. *See generally* Note, *The Advent of DNA Databanks: Implications for Information Privacy*, 16 AM. J.L. & MED. 381 (1990); Hayes, *DNA Fingerprinting Called Privacy Threat*, Wall St. J., Feb. 6, 1990, at B1, col. 1.

167. LA. REV. STAT. ANN. § 441.1 (West Supp. 1990) ("Evidence of deoxyribonucleic acid profiles, genetic markers of the blood, and secretor status of the saliva offered to establish the identity of the offender of any crime is relevant as proof in conformity with the Louisiana Code of Evidence.").

168. In a civil or criminal trial or hearing, the results of DNA analysis . . . are admissible in evidence without antecedent expert testimony that DNA analysis provides a trustworthy and reliable method of identifying characteristics in an individual's genetic material upon a showing that the offered testimony meets the standards for admissibility set forth in the Rules of Evidence.

MINN. STAT. ANN. § 634.25 (West Supp. 1990) A companion section addresses a problem with the statistical frequency data:

> In a civil or criminal trial or hearing, statistical population frequency evidence, based on genetic or blood test results, is admissible to demonstrate the fraction of the population that would have the same combination of genetic markers as was found in a specific human biological specimen.

MINN. STAT. ANN. § 634.26 (West Supp. 1990). Both of these sections must be read in light of State v. Schwartz, 447 N.W.2d 422 (Minn. 1989). *See supra* note 28. The *Schwartz* court found the Minnesota Rules of Evidence incompetent to ensure the reliability of DNA evidence. 447 N.W.2d at 424. The court, instead, reaffirmed its commitment to the *Frye* standard. *Id.* The subsequent enactment of sections 634.25-.26 are clear attempts by the Minnesota legislature to remove the *Frye* requirement in future DNA cases.

169. Section 10-915 of Maryland's Courts and Judicial Proceedings Code, entitled "Admissibility of DNA profiles," provides:

(a) Definitions—(1) In this section the following words have the meanings indicated.

ically directing their courts to admit all DNA evidence categorically. In light of *Castro*, these statutes may be a premature and unacceptably broad recognition of the procedure. Recent legislative actions in both Minnesota[170] and Maryland[171] appear to eliminate the possibility of a preliminary *Frye* hearing (or, for that matter, a *Castro* third-prong hearing) in criminal cases employing DNA fingerprinting techniques. The Maryland statute also reveals some challenging language that may require judicial elaboration.

First, the Maryland statute states that "[i]n any criminal proceeding, the evidence of a DNA profile is admissible."[172] "DNA profile" is defined as "an analysis of DNA resulting in the identification."[173] It is unclear, however, whether this definition means *any* analysis or a particular form of DNA analysis.[174] Since the only technique reported in any Maryland decision[175] was Cellmark's RFLP, this analysis is possibly the only one contemplated by the legislature.[176]

Consequently, the statute may allow non-Cellmark procedures to be admitted in Maryland courts. Statutory approval of these techniques (without

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(2) "Deoxyribonucleic Acid (DNA)" means the molecules in all cellular forms that contain genetic information in a patterned chemical structure of each individual.

(3) "DNA profile" means an analysis of DNA resulting in the identification of an individual's patterned chemical structure of genetic information.

(b) Purposes—In any criminal proceeding, the evidence of a DNA profile is admissible to prove or disprove the identity of any person.

(c) Prerequisites—If the State decides to offer evidence of a DNA profile in any criminal proceeding, the State shall:

(1) At least 15 days before the criminal proceeding, notify in writing the defendant or the defendant's attorney and mail, deliver, or make available to the defendant or the defendant's attorney a copy of any report or statement to be introduced; and

(2) Upon written demand of the defendant filed at least 5 days before the criminal proceeding, require the presence of any person in the chain of custody as a prosecution witness.

MD. CTS. & JUD. PROC. CODE ANN. § 10-915 (1989).

170. MINN. STAT. ANN. § 634.25 (West Supp. 1989).

171. MD. CTS. & JUD. PROC. CODE ANN. § 10-915 (1989).

172. *Id.* at § 10-915(b).

173. *Id.* at § 10-915(a)(3).

174. *Id.*

175. Yorke v. State, 315 Md. 578, 588, 556 A.2d 230, 235 (1989) (Cellmark single locus procedure); Cobey v. State, 80 Md. App. 31, 34, 559 A.2d 391, 392 (same), *cert. denied*, 317 Md. 542, 565 A.2d 670 (1989).

176. The legislative history of the statute offers little guidance. In the preamble to House Bill 711, approved May 19, 1989, at the same time the defense in *Castro* was preparing to conclude its attack on the Lifecodes procedure, William Donald Schaefer, Governor of Maryland, described the DNA technique optimistically: "[The] [m]eans of identifying that unique DNA structure have been refined far beyond any previous means of human tissue analysis, to a level of scientific accuracy that approaches an infinitesimal margin of error . . . ." 1989 Md. Laws 2892, 2893 (approved May 19, 1989, ch. 430).

preliminary *Frye*-type scrutiny) promises to affect profoundly future challenges to new DNA procedures. In its current formulation, for example, the statute would presumably allow the introduction of a Cetus-type test in a criminal proceeding. Because the Cetus-type test is unknown to the Maryland courts and because it is fundamentally different[177] from RFLP, before the results might be admitted, a judge should conduct a *Frye* hearing to satisfy preliminary questions of reliability of both the theoretical and technical aspects of the procedure. Yet, the Maryland statute appears to extinguish inappropriately any challenge to the admissibility of DNA identifications, whether *Frye* tested or not, in favor of a generalized examination of the weight of the evidence presented. *Castro* demonstrates that the admissibility question has not been settled, even for existing and frequently used RFLP techniques. To decree that future DNA identification methods have statutory license for introduction in Maryland criminal proceedings would vitiate the principles underlying the *Frye* and *Castro* safeguards.

If the Maryland legislature permitted its courts to follow the procedures recommended by the *Castro* court, it might avoid the problems raised by the premature admission of a new DNA technique and further ensure that particular applications of DNA fingerprinting tests are reliable before they are presented to a jury.

VI. STANDARDIZATION

Some legal commentators have urged the admissibility of reliable DNA typing test results, even in the absence of a national standardized system of procedures.[178] In light of *Castro*, this confidence may be misplaced. Standards for DNA analysis in paternity disputes have already been published by

177. *See Identification Tests*, *supra* note 5, at 905 n.4 (Cetus procedures "significantly different" from those used by Cellmark and Lifecodes); Thompson & Ford, *supra* note 4, at 50 (Cetus techniques "differ markedly").

178. *See, e.g.*, *Identification Tests*, *supra* note 5:

> The lack of a standardized national system should not affect the admissibility of any particular system as long as the test is reliable and the laboratory offering the test uses sound testing procedures. Although the lack of a national system does create some problems of uniformity, it does not affect the reliability of competing systems and should not be a bar to their use.

Id. at 930. Determining whether a particular test is reliable, however, is difficult in the absence of recognized and agreed-upon standards. Admitting DNA tests on a case-by-case basis allows for disparate evaluations of reliability, even more so where the defense fails to challenge a particular laboratory's application of DNA theory and technique. Moreover, where the evidence is used in plea negotiations, the possibility for challenge is eliminated or reduced, and without standardization, DNA evidence influences the criminal justice system and should be governed by some minimum standards.

the American Association of Blood Banks (A.A.B.B.).[179] While these standards should not be followed by forensic laboratories (because of the drastically different goals and uses of criminal evidence), some of the procedures performed in *Castro* would have been unacceptable even under the less stringent A.A.B.B. standards.[180]

Three separate studies have been exploring the standardization of DNA typing procedures for forensic use. The Technical Working Group on DNA Analysis Methods (TWGDAM), coordinated by the Federal Bureau of Investigation, is comprised of thirty-one scientists from crime laboratories nationwide.[181] TWGDAM has released two proposals: one suggests minimum guidelines for quality assurance in RFLP analysis[182] and the other offers a model for creation and maintenance of a DNA data bank for cataloguing the identity of violent criminals.[183] TWGDAM's quality assurance guidelines detail standards and procedures for operation of an RFLP laboratory, including organization of the laboratory, personnel qualifications, and procedures for documentation, materials and equipment, validation, evidence handling, internal controls, analysis and reporting, and proficiency.[184] The TWGDAM guidelines are written broadly and are subject to revision as technology progresses.[185]

In July 1990 The Office of Technology Assessment (OTA) published a report designed to "illustrate a range of options for the U.S. Congress."[186] The OTA study concluded that "[s]tandards are necessary if high-quality DNA forensic analysis is to be ensured, and [that] the situation demands immediate attention."[187] The study identified two types of standards for im-

179. *See* AMERICAN ASSOCIATION OF BLOOD BANKS, PATERNAGE COMMITTEE PROPOSED STANDARDS FOR TESTS INVOLVING DNA POLYMORPHISMS (rev. Feb. 1988) (on file at the offices of THE JOURNAL OF CONTEMPORARY HEALTH LAW AND POLICY, The Catholic University of America, The Columbus School of Law, Washington, D.C. 20064).

180. For example, the A.A.B.B. standards require the testing of a known heterozygote DNA in the control lane for each hybridization. As discussed *supra* text accompanying notes 115-17, Lifecodes failed to record the origin of the control lane DNA for the watch sample.

181. No commercial labs are permitted to participate in TWGDAM, although Cellmark says that it has contributed copies of its procedures to the group. Stolorow interview, *supra* note 10.

182. Technical Working Group on DNA Analysis Methods, *Guidelines for a Quality Assurance Program for DNA Restriction Fragment Length Polymorphism Analysis, reprinted in* J. KIRBY, *supra* note 39, app. I at 261-78.

183. Technical Working Group on DNA Analysis Methods, *The Combined DNA Index System (CODIS): A Theoretical Model*, (Oct. 1989), *reprinted in* KIRBY, *supra* note 39, app. II at 279-317.

184. *Id.*

185. *Id.* at 263.

186. GENETIC WITNESS, *supra* note 10, at iii.

187. *Id.* at 10.

plementation: technical and operational.

> [Technical standards] include such issues as proper reagents and gel controls; electrophoresis conditions; rules to match DNA banding patterns; the extent that computer-assisted matching should be permitted; and the population data to compute the likelihood of matches. Operation standards include elements such as record-keeping and proficiency testing; they are likely to be more controversial than technical standards, for historically, attempts to regulate laboratory practices in any sector have met with resistance. . . .[188]

The study went on to say that "[a]ccreditation, licensing, and certification are among the mechanisms of quality assurance that could be applied to facilities performing forensic DNA analysis."[189] In addition to the TWGDAM and OTA studies, a working group of the National Science Foundation is considering the standardization issue and has yet to issue a report on its findings.

Both Cellmark and Lifecodes say that they would welcome standardization, insisting that their current procedures would meet any protocol proposed by an authoritative source.[190] However, commercial labs, such as Cellmark and Lifecodes, might resist intense outside scrutiny because of their proprietary interest in laboratory procedures.[191] Courts must balance property rights in technical procedures against the more pressing need to establish minimum uniform controls over those who can place seemingly authoritative evidence before the criminal justice system.

In the context of *Castro*'s third-prong—reliability of a particular set of tests (as a condition for admissibility as a matter of law)—procedural standardization would serve as the needed objective measure for accuracy. Yet, as evidenced by the TWGDAM proposal,[192] standards governing DNA typing must be flexible enough to accommodate scientific advancement (and refinement) of the techniques. The need for flexibility, however, should not prevent establishment of parameters to govern both the RFLP and PCR methods.[193]

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188. *Id.* at 13-14.

189. *Id.*

190. Wexler interview, *supra* note 10; Stolorow interview, *supra* note 10.

191. During a recent *Frye* hearing, Cellmark was able to get a protective order covering its confidential lab protocols. Thompson & Ford, *supra* note 4, at 59 n.71.

192. *See supra* text accompanying note 184.

193. The issuance of standards must be accompanied by some means of enforcement. While the TWGDAM study appears to rely on peer-review and periodic audits, *see* J. KIRBY, *supra* note 39, at 269, 273, it is possible that Congress will establish and enforce DNA typing standards. Congressman Don Edwards, Chairman of the House Subcommittee on Civil and

VII. CONCLUSION

The introduction of DNA evidence raises a multitude of questions outside the scope of this Comment.[194] Yet, by itself, the *Frye* standard, emerging from the *Castro* decision, appears unable to address the complexities of DNA typing. In addition to the deficiencies found in *Castro*, *Frye*'s 'generally accepted' standard poses other problems that will be evident in subsequent cases involving DNA evidence: because some *Frye* jurisdictions may rely upon prior appellate decisions and peer review articles to test new pro-

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Constitutional Rights, has said he is considering legislation "to bring about the development of tough standards." Marcotte, *Report: DNA Tests Valid*, A.B.A. J., Oct. 1990, at 26.

194. For example, the need for expert testimony in DNA cases is obvious; *Castro* demonstrates the potential for successful challenge of DNA fingerprinting techniques. Does, then, an indigent have the right to a court-appointed expert to rebut the prosecution's case? Quite possibly, the complexity of DNA-dependent cases may trigger mandatory appointments; refusal to appoint an expert may violate the defendant's sixth and fourteenth amendment guarantees. *See, e.g.*, Williams v. Martin, 618 F.2d 1021, 1026 (4th Cir. 1980); *cf.* United States v. Stifel, 433 F.2d 431, 441 (6th Cir. 1970) (when government uses expensive neutron activation analysis as fact-finding tool, it must pay for similar tests performed on behalf of indigent defendants), *cert. denied*, 401 U.S. 994 (1971). It is axiomatic that an indigent's successful challenge to the prosecution's case can only come from court-appointed experts. This is especially true in jurisdictions applying the relevancy approach: "[T]he adequacy of the relevancy approach depends, in large measure, on full discovery, the opportunity to reexamine evidence, and the appointment of defense experts. Without these safeguards, cross-examination and refutation are difficult, if not impossible." GIANNELLI & IMWINKELRIED, *supra* note 2, at § 1.6(D). Although expert witnesses in almost every case will be needed to challenge DNA fingerprinting, expert judges, versed in the intricacies of molecular biology, population statistics, chemistry and genetics, will probably not be required. *See, e.g.*, Bethune v. Azios, No. 01-88-00874-cv, slip op. (Tex. Ct. App. Oct. 6, 1988), 1988 Tex. LEXIS 2491 (overruling Motion for Leave to File a Petition for Writ of Mandamus where relator filed a motion for recusal on grounds that case involving DNA typing required a board certified criminal law specialist).

Because the DNA fingerprinting technique is in its infancy, serious questions will also be raised about actual expertise of expert witnesses. Further, considering that the pool of experts is currently limited, the scientific community may not easily accommodate demands of the state and defense bars. Standardization of the technique should diminish these problems; with an objective and widely recognized set of standards, a court may measure any given test and weigh challenges to it.

Another problem that may be encountered and is most likely to arise where defense counsel seeks to use the evidence for purposes of exculpation, *see, e.g.*, discussion of Gary Dotson case, *supra* note 153, is the preservation of the DNA sample itself. The state's duty to preserve evidence for purposes of exculpation is limited. *See* Arizona v. Youngblood, 488 U.S. 51, 58 (1988) (good faith failure by police to preserve potentially exculpatory evidence does not violate the due process clause); California v. Trombetta, 467 U.S. 479, 489 (1984) (no duty to preserve breath samples; intoxilyer is so accurate that preservation is not likely to be exculpatory); *People v. Sims*, A.B.A. J., Sept. 1989, at 105 (in the absence of bad faith, indictment does not violate due process clause where police in rape case failed to reveal potentially exculpatory DNA evidence). As the DNA technique travels through the courts, it is bound to encounter resistance. This resistance, however, is wholly dependent upon a challenger's resolve and resources to mount an effective and comprehensive case against the introduction of any specific case sample.

cedures,[195] the potential exists, not only for great inconsistency among the courts, but also for the admission of tests prior to challenge through the pretrial adversary process. Likewise, the general relevancy approach offers no guarantee that DNA evidence will be excluded if the proffered tests lack a uniform measure of reliability.[196]

Because of (i) the deficiencies in laboratory application of the DNA identification technique displayed in *Castro*, (ii) the apparent lack of consensus among scientists as to the proper reliable method of DNA analysis, and (iii) the variations existing in DNA typing methods and procedures, laboratory protocols, and the degree of compliance achieved on particular samples in particular laboratories, courts should cautiously assess the reliability of specific test results prior to admission of the evidence.

In jurisdictions such as Maryland and Minnesota, where introduction of DNA evidence has been summarily endorsed by statute, courts should fashion pre-admission standards in order to ensure proper application of the technique. And where these courts encounter a DNA identification method that has not, in spite of generalized acceptance under a statutory rubric, gained judicial recognition in their state, it would be both inappropriate and inadequate to allow the results of a new analytical method to be introduced without preliminary scrutiny of the technique's theoretical basis. Moreover, in jurisdictions accepting the theory and techniques behind DNA fingerprinting, this judicial recognition should not be extended to embrace a laboratory's dynamic procedural application to a particular set of test results.

Many of these problems, however, may be resolved upon issuance of authoritative and harmonized standards governing DNA analysis. Yet until standardization offers the needed objective measure of a particular laboratory's performance of DNA analysis, the three-prong approach to preliminary consideration of DNA evidence advanced in *Castro*, and adopted by the Eighth Circuit in *United States v. Two Bulls*, offers the only current method of ensuring both the proper management of the technique and its reliability.

DNA evidence has revolutionized the field of forensic evidence. It has the potential to offer an accurate method of identification that will, over time, allow for a relatively precise means of both inculpation and exculpation. As such, its introduction in the courts of the United States should be welcomed.

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195. *See* GIANNELLI & IMWINKELRIED, *supra* note 2, at § 1-5(B)(3)-(C).

196. Unlike the *Frye* test, the relevancy approach does not attempt to assure the reliability of novel scientific evidence prior to admission. Although some evidence will be screened out by a court applying the relevancy approach, most innovative techniques will gain admissibility, at which time any deficiencies in the technique should be exposed through traditional adversary trial procedures.
GIANNELLI & IMWINKELRIED, *supra* note 2, at § 1-6(D).

Yet, given the dramatic disparity between the few samples that have undergone judicial scrutiny and the reported number of samples tested, the potential clearly exists for unreliable DNA evidence to influence dramatically criminal adjudication outside the courts' adversarial forum. Even jurisdictions providing for pretrial scrutiny of DNA evidence should seek the standardized scientific consensus that will establish DNA fingerprinting as a credible, evidentiary staple in the criminal justice system.

John Caleb Dougherty