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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].


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).


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. 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. DNA evidence has also been introduced, and almost always admitted, in scores of criminal cases. However, while DNA technology has been heralded by prosecutors.

9. 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.


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.


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,” its place in the criminal justice system is not yet assured. 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. Despite concerns with the technique's reliability, no criminal or civil court, until recently, has held the evidence inadmissible to prove identity.

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. Cumin, 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].


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.


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 States17 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


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.

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. 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. 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.

Jurisdictions that do not adopt the Frye test apply a general "relevancy" test reflected in the Federal Rules of Evidence. 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. 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. First, to assess the probative value of the evidence, courts must consider the reliability of the scientific evidence, 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." Next, the court should identify any "countervailing dangers" that may accompany introduction of the evidence. 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).
24. GIANNELLI & IMWINKELRIED, supra note 2, at § 1-6.
25. Id. at § 1-6(A).
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.
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technique as "DNA fingerprinting" may confer an unwarranted connotation of the technique's accuracy.\textsuperscript{30} Furthermore, the statistical frequency data\textsuperscript{31} accompanying DNA evidence may increase the risk of unfair prejudice or confusion contemplated by the federal rules.\textsuperscript{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.\textsuperscript{33}

Whichever test is used, \textit{Frye} or the relevancy test,\textsuperscript{34} the admissibility of

\textsuperscript{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. Cumin, 409 Mass. 218, —, 565 N.E.2d 440, 441 n.2 (1991).

\textsuperscript{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. \textit{See, e.g., infra} text accompanying notes 70-72.

\textsuperscript{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 . . . ."

\textsuperscript{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] the 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.


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.

\textsuperscript{34} \textit{See generally} United States v. Two Bulls, 918 F.2d 56 (8th Cir. 1990) (finding \textit{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. 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. Currently, laboratories use


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-

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.


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. The structure of DNA is most frequently referred to as a “double helix,” best imagined as a long ladder twisted along its vertical axis. The rungs of the ladder describe bonds between bases. According to the “base-pair rule,” each base will bond only with its complement. 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. 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. 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. All genes may have two or more different versions called alleles. 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. The likelihood that two individuals share identical polymorphic genes is extremely rare and can be estimated through population genetics.

2. Restriction Fragment Length Polymorphism (RFLP)

To begin the RFLP procedure, technicians extract DNA from the foren-
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sic sample through treatment with chemicals and enzymes. In order to identify the polymorphic regions, restriction enzymes are introduced into the DNA through a process known as "digestion" or "restriction digestion." 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.

The DNA fragments are then lined up according to length to allow measurement and comparison by a process called "gel electrophoresis." 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 and to confirm that all the DNA has been removed from the gel when the DNA is transferred to a stable membrane.


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.


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

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.” 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. 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.

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. Gianelli & 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.\textsuperscript{70} In some instances, laboratories have assigned samples a statistical probability of random occurrence at one in 700,000,000.\textsuperscript{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.\textsuperscript{72}

\section*{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.\textsuperscript{73} The Cetus technique permits rapid amplification of the targeted sequence of DNA through a procedure known as polymerase chain reaction (PCR).\textsuperscript{74} The PCR method amplifies a single strand of denatured DNA, thereby producing multiple copies of the original DNA sequence.\textsuperscript{75} The major advan-
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.
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*, the Supreme Court of Bronx County began a preliminary hearing that would take over twelve weeks, producing a transcript of over five thousand pages. In the end, Judge Sheindlin held the evidence inadmissible to prove that the DNA in the watch's bloodstain matched the victim's (inclusion).

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, 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.

The *Castro* court employed a three-prong test to determine the admissibility of the DNA evidence. 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."  

Attorneys Barry Scheck and Peter Neufeld led the defense of Joseph Castro. While their efforts are best chronicled elsewhere, 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).

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:

"Given 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.
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The defense attack in Castro spanned both the theoretical and procedural aspects of the Lifecodes test. The defense brief filed in the Castro hearing was a step-by-step challenge to the Lifecodes methodology. 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. 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' memorandum. 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, Lifecodes made no reference to this band. At the hearing, however, all of the prosecution experts admitted to seeing a band at 6kb. 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. The re-hybridization produced conflicting results. 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. 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."

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-
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Degradation smears the DNA along the lane, producing a broad and blurry print and potentially obscuring bands higher on the autorad. The probe for D2S44 showed a homozygous band at about 10.25kb in the lane of the deceased. 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. 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." 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. 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, Manager, 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\textsuperscript{111} and suggested that in the case of D2S44, Lifecodes technicians could have used a nonpolymorphic probe to detect loci above 13kb.\textsuperscript{112} The conflicting expert testimony on the matter, however, was sufficient to place the issue before the jury.\textsuperscript{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.\textsuperscript{114} These are only two of the recommendations the court advanced in an effort to solve the apparent procedural deficiencies in Lifecodes' practice.

\textbf{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\textsuperscript{115} revealed the blood to be of female origin. To determine whether hybridization occurs correctly, technicians normally pre-

\textsuperscript{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.

\textsuperscript{112} \textit{Id.} at 971, 545 N.Y.S.2d at 994.

\textsuperscript{113} \textit{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 \textit{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 mis-read the size markers: the \textit{Alu} hybridization actually extended only to the 9.8-kb marker.

\textsuperscript{114} See Castro, 144 Misc. 2d at 996, 545 N.Y.S.2d at 997.

\textsuperscript{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, \textit{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. 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.
120. Castro, 144 Misc. 2d at 976, 545 N.Y.S.2d at 997.
origin that we have not been able to identify." Their additional attempts to identify the two suspect bands as nonhuman were unsuccessful. 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. The court further believed that additional experiments might have discounted the two additional bands as contaminants.

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

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

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. The

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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.


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.\(^\text{128}\)

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\(^\text{129}\) only when technicians follow this estimate with an objective qualitative measurement to ensure accuracy.\(^\text{130}\) Lifecodes’ matching rules would declare a match between two measured fragments if the difference in positions fell within three standard deviations,\(^\text{131}\) 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.\(^\text{132}\) 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

\(\text{128. } \text{Castro, 144 Misc. 2d at 977 n.13, 545 N.Y.S.2d at 998 n.15.}\)
\(\text{129. } \text{Contra Lander, supra note 104, at 502-03.}\)
\(\text{130. } \text{Castro, 144 Misc. 2d at 977, 545 N.Y.S.2d at 998. Lifecodes employs a computer-digitizing apparatus, considered to be extremely accurate, as an objective measuring tool. Id.; Lander, supra note 104, at 502.}\)
\(\text{131. } \text{Lifecodes’ standard deviation (s.d.) is reported to be a difference in position corresponding to 0.6 of molecular weight. Based upon this observation, Lifecodes announced a matching rule: two fragments are said to match if their band positions differ by less than 3 s.d.’s. This same matching rule was prescribed by Lifecodes for the samples in *Castro*. Thus, if fragments appeared within the 3 s.d. range, they were considered indistinguishable, and their average size reported. Lander, supra note 104, at 502. In *Castro*, however, the results produced from Lifecodes’ computer-digitizing showed that the bands observed for D2S44 and D17S79 differed in position greater than 3 s.d.’s, falling outside the declared rule, thus indicating a nonmatch. Id. To answer the seemingly self-contradictory result, Lifecodes stated that the objective, computer-digitized measurements were not used to pronounce a match. Rather, Lifecodes’ decision was based solely upon a visual matching of the band positions. Id.}\)
\(\text{132. } \text{Castro, 144 Misc. 2d at 967-69, 545 N.Y.S.2d at 995.}\)
group. 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.” The Castro court labeled this particular Lifecodes practice “dubious” 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.”

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.

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

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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.\footnote{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.\footnote{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.\footnote{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.\footnote{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.\footnote{142} Finally, the court decried the use of differing forensic testing should be accompanied by stricter laboratory procedures. See Memorandum, \textit{supra} note 94, at 15.

\footnote{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. \textit{Id.;} Lander, \textit{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. \textit{Id.} In \textit{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. \textit{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, \textit{supra} note 10 (mixing experiments performed seldom to never); Stolorow interview, \textit{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, \textit{supra} note 104, at 501.

\footnote{139} Castro, 144 Misc. 2d at 971, 545 N.Y.S.2d at 994.

\footnote{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. \textit{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, \textit{supra} note 10.

\footnote{141} Castro, 144 Misc. 2d at 971, 545 N.Y.S.2d at 994.

\footnote{142} \textit{Id.} at 972, 545 N.Y.S.2d at 994. Lifecodes attributed the \textit{Castro} mix-up to a failure of communication within the lab. Indeed, many of the procedures criticized have been improved since the \textit{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 \textit{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

includes 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-
posed a similar notice requirement on state prosecutors.\textsuperscript{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.\textsuperscript{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.\textsuperscript{156}

Compared with the notice requirement, the documentation requirements are certainly more onerous. The \textit{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\textsuperscript{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.\textsuperscript{158}

If promulgated, uniform standards should find a place in \textit{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 \textit{Castro} holding, it will be increasingly difficult to chal-


\textsuperscript{155} See, e.g., \textit{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 . . . ").

\textsuperscript{156} \textit{Id.}

\textsuperscript{157} Maryland has partially codified these prescriptions. \textit{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.").

\textsuperscript{158} \textit{Castro}, 144 Misc. 2d at 979, 545 N.Y.S.2d at 999.
Challenges 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.\textsuperscript{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.\textsuperscript{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."\textsuperscript{161} As to what constituted the requisite unreliability, the court offered only the test results in Castro.\textsuperscript{162}

\textsuperscript{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.

\textsuperscript{160} As recently noted by the court in Commonwealth v. Cumin, 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.

\textsuperscript{161} Castro, 144 Misc. 2d at 979, 545 N.Y.S.2d at 999.

\textsuperscript{162} By unveiling the inconsistencies and errors in Lifecodes' procedures, the Castro case may cast a shadow on 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-

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 Gianelli & 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 pronounce-ment. 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. In addition, some states have prescribed the use of DNA identification for paternity disputes. Still other legislatures have established DNA data banks to track known criminal offenders. 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.

Louisiana, Minnesota, and Maryland have enacted statutes specif-

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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).


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).


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\textsuperscript{170} and Maryland\textsuperscript{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.”\textsuperscript{172} “DNA profile” is defined as “an analysis of DNA resulting in the identification.”\textsuperscript{173} It is unclear, however, whether this definition means any analysis or a particular form of DNA analysis.\textsuperscript{174} Since the only technique reported in any Maryland decision\textsuperscript{175} was Cellmark's RFLP, this analysis is possibly the only one contemplated by the legislature.\textsuperscript{176}

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

\begin{itemize}
\item (2) “Deoxyribonucleic Acid (DNA)” means the molecules in all cellular forms that contain genetic information in a patterned chemical structure of each individual.
\item (3) “DNA profile” means an analysis of DNA resulting in the identification of an individual’s patterned chemical structure of genetic information.
\item (b) Purposes—In any criminal proceeding, the evidence of a DNA profile is admissible to prove or disprove the identity of any person.
\item (c) Prerequisites—If the State decides to offer evidence of a DNA profile in any criminal proceeding, the State shall:
\begin{itemize}
\item (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
\item (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.
\end{itemize}
\end{itemize}


172. Id. at § 10-915(b).
173. Id. at § 10-915(a)(3).
174. Id.


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: “[T]he [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 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. In light of *Castro*, this confidence may be misplaced. Standards for DNA analysis in paternity disputes have already been published by

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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.). 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.

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. TWGDAM has released two proposals: one suggests minimum guidelines for quality assurance in RFLP analysis and the other offers a model for creation and maintenance of a DNA data bank for cataloging the identity of violent criminals. 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. The TWGDAM guidelines are written broadly and are subject to revision as technology progresses.

In July 1990 The Office of Technology Assessment (OTA) published a report designed to "illustrate a range of options for the U.S. Congress." 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." The study identified two types of standards for im-

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.
184. Id.
185. Id. at 263.
186. Genetic Witness, supra note 10, at iii.
187. Id. at 10.
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Implementation: 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. . . .

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." 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. However, commercial labs, such as Cellmark and Lifecodes, might resist intense outside scrutiny because of their proprietary interest in laboratory procedures. 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, 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.

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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. 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-

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." Gianelli & 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; intoxilyzer 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.
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The potential exists, not only for great inconsistency among the courts, but also for the admission of tests prior to challenge through the pre-trial 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.

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.

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