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ARGUE WITH SCIENCE? THE ADMISSIBILITY DEBATE SURROUNDING DNA IDENTIFICATION

The utilization of scientific evidence in litigation has increasingly gained acceptance in the courtroom. Examples of evidentiary tools that have been employed include radar, blood testing, and medical evidence. Before scientific evidence is admitted in a trial, the scientific technique must pass the Frye test: general acceptance in its particular field. Frye v. United States, 293 F. 1013, 1014 (D.C. Cir. 1923).

1 See, e.g., United States v. Sanchez, 829 F.2d 757, 757 (9th Cir. 1987) (permitting identification through use of forward-looking infrared device); Williams v. State, 312 S.E.2d 40, 52 (Ga. 1983) (scientific analysis of fiber evidence played crucial role in murder trial); State v. Wheeler, 496 A.2d 1382, 1386-89 (R.I. 1985) (admitting voice spectrographic identification); Murder Case, Focus Turns to Science, N.Y. TIMES Mar. 26, 1990, at 24 (murder trial focused on scientific evidence consisting of DNA, fingerprint and hair analyses). At least one court found medical evidence sufficient as scientific evidence. See State v. Armstrong, 369 S.E.2d 870, 877 (W. Va. 1988) (court found bite-mark evidence sufficiently reliable to allow judicial notice); see also RONALD L. CARLSON ET AL., MATERIALS FOR THE STUDY OF EVIDENCE 217 (1983) (noting that it is “virtually impossible” to try major personal injury case without detailed medical evidence and that medical evidence is also becoming necessary in criminal cases).


2 See, e.g., State v. Gerdes, 191 N.W.2d 428, 431 (Minn. 1971) (extending judicial notice to stationary radar); People v. Knight, 72 N.Y.2d 481, 486, 550 N.E.2d 1273, 1275, 534
and fingerprinting. Since only valid and reliable evidence is useful to the trier of fact, all novel techniques and technologies are necessarily subject to special admissibility hurdles. A current test,


We think the time has come when we may recognize the general reliability of radar speedometer as a device for measuring the speed of a moving vehicle and that it will no longer be necessary to require expert testimony in each case as to the nature, function or scientific principles underlying it. Almost daily, reproductions by photography, X-rays, electroencephalograms, electrocardiograms, speedometer readings, time by watches and clocks, identity by fingerprinting, and ballistic evidence, among a variety of kindred scientific methods, are freely accepted in our courts for their general reliability, without the necessity of offering expert testimony as to the scientific principles underlying them. The use of radar for speed detection may now be said to fall in this category.


The Breathalyzer, which measures blood-alcohol content, was recognized by the New York legislature as reliable when it provided that “the court shall admit evidence of the amount of alcohol or drugs in the defendant's blood as shown by a [breathalyzer] test...” N.Y. VEH. & TRAF. § 1195 (McKinney 1986 & Supp. 1992): see People v. Donaldson, 36 A.D.2d 37, 40, 319 N.Y.S.2d 172, 176 (4th Dep't 1971). The Donaldson court stated that “the Legislature has obviously determined that breath tests, if conducted in accordance with proper procedures, are scientifically reliable for determining the percentage of alcohol in the blood.” Id.


See Giannelli, supra note 1, at 1247. “N]ovel scientific evidence presents significant reliability problems that may result in erroneous verdicts.” Id. Professor Giannelli further explains that only reliable evidence contributes to the fact-finding function of a trial, and that reliability depends in part upon the validity of the principle and technique used. Id. at 1200-01: see also CARLSON, supra note 1, at 218. Proponents of expert witnesses should elicit testimony about the validity of the theory and reliability of the instrument. Id.: MCCORMICK ON EVIDENCE § 203, at 873 (James W. Strong ed., 4th ed. 1992) (noting that some commentators have suggested substituting validity and reliability test for extent of acceptance test).
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DNA profiling, has been the subject of much scrutiny by courts and commentators.8

8 See, e.g., Gordon, supra note 1, at 1 ("DNA tests offer a virtually infallible method of identifying a rapist or murderer from trace amounts of biological material left at the scene of the crime."). The scientific technique used to compare and analyze the DNA patterns from two samples has been termed "DNA profiling," "DNA fingerprinting" or "DNA typing" and has been heralded as a "revolutionary forensic technique." Shannon Brownlee, Courtroom Genomics, U.S. NEWS & WORLD REPORT. Jan. 27, 1992, at 60; see Janet C. Hoeffel, The Dark Side of DNA Profiling: Unreliable Scientific Evidence Meets the Criminal Defendant, 42 STAN. L. REV. 465, 465 n.3 (1990) (highlighting different names of DNA testing). But see Commonwealth v. Curnin, 565 N.E.2d 440, 441 n.2 (Mass. 1991) (rejecting term "DNA fingerprinting" because it suggests conclusiveness and is therefore misleading).

DNA identification has been applied in both civil and criminal cases with five private laboratories and the Federal Bureau of Investigation’s forensic lab providing their services. See LIFECODES CORPORATION. INFORMATION PACKET. at DNA Identity Testing Pamphlet 2 (1991) [hereinafter LIFECODES] (available from Lifecodes Corp., Valhalla, NY). Lifecodes Corporation recommends its DNA-PRINT Test for use in the forensic and paternity areas, claiming "[a] minimum paternity probability of 99% for all ethnic groups is ensured!" Id. at DNA Paternity Test Pamphlet. For further information on the use of DNA profiling in paternity suits, see generally Aravinda Chakravarti, Ph.D. & Ching Chun Li, Ph.D., The Effect of Linkage on Paternity Calculations, in 1983 INCLUSION PROBABILITIES IN PARENTAGE TESTING 411, 416-17 (Rene J. Duquesnoy, Ph.D., ed., 1983) (genetic evidence used to exonerate suspect males in paternity dispute); Mary K. Kisthardt, Of Fatherhood, Families and Fantasy: The Legacy of Michael H. v. Gerald D., 65 TUL. L. REV. 585, 592 n.60 (1991) (discussing accuracy of DNA testing in establishing paternity); Ronald J. Richards, DNA Fingerprinting and Paternity Testing, 22 U.C. DAvis L. REV. 609, 645-51 (1989) (suggesting use of DNA testing for positive identification in paternity cases).

7 See, e.g., United States v. Two Bulls, 918 F.2d 56, 58 (8th Cir. 1990) (DNA profiling relatively new and subject of controversy in legal and scientific communities); People v. Castro, 144 Misc. 2d 956, 957, 545 N.Y.S.2d 985, 986 (Sup. Ct. Bronx County 1989). The Castro court undertook an extensive investigation into the DNA forensic identification tests during a twelve-week pre-trial hearing which produced a transcript of approximately 5000 pages. Id.

Although the previous cases denied admission of DNA typing, several courts have, after considerable analysis, admitted the test results. See Andrews v. State, 533 So. 2d 841, 850-51 (Fla. Dist. Ct. App. 1988) (admitted 'genetic fingerprint' evidence based on relevancy test); People v. Wesley, 140 Misc. 2d 306, 332, 533 N.Y.S.2d 643, 659 (Albany County Ct. 1988) (court admitted DNA evidence but reduced probability statistics by power of ten); see also State v. Ford, 392 S.E.2d 781, 783 (S.C. 1990) (recognizing reliability of DNA evidence).

Many state courts have admitted DNA evidence upon concluding that it satisfies the general acceptability test of Frye v. United States. See infra notes 88-95 and accompanying text (discussing Frye test): see also People v. Shi Fu Huang, 145 Misc. 2d 513, 517, 546 N.Y.S.2d 920, 923 (Nassau County Crim. Term 1989) (DNA profiling meets test of general acceptance); Glover v. State, 787 S.W.2d 544, 548 (Tex. Ct. App. 1990) (DNA admissible because principles, procedures, and technology generally accepted); State v. Woodall, 385 S.F.2d 253, 260 (W.Va. 1989) (DNA admissible because deemed reliable by geneticists and biochemists).

This Note will analyze the admissibility of DNA profiling evidence. Part One will examine the scientific background of DNA "genetic marking," the procedures currently in use for determining the likelihood of a match between two DNA samples, and the accuracy and reliability of population genetics statistics. Part Two will enumerate the different admissibility standards used in the Eighth and Second Circuits of the United States Court of Appeals. Part Three will consider the rationales of these courts and address whether a judge or jury should decide if proper testing procedures were followed. This question will be examined in light of concerns about possible unfair prejudice to the criminal defendant and evidentiary foundational requirements. Finally, Part Four will discuss how courts might decide this issue in the future, and suggest that a recent New York case provides a viable alternative to the tests adopted in the federal circuits.

I. THE SCIENCE OF DNA PROFILING

A. Genetic Background

Deoxyribonucleic acid ("DNA") is the substance in chromosomes which carries the genetic characteristics that make each of DNA typing exist, that additional techniques must be developed, tested, published in peer-reviewed journals, and debated before accepting technology and admitting novel scientific evidence): William C. Thompson & Simon Ford, DNA Typing: Acceptance and Weight of the New Genetic Identification Tests, 75 VA. L. REV. 45, 46-51 (1989) (noting development of electrophoresis technique): Charles L. Williams, DNA Fingerprinting: A Revolutionary Technique in Forensic Science and Its Probable Effects on Criminal Evidentiary Law, 37 DRAKE L. REV. 1, 18 (1987-88) (admission of test results into evidence in criminal cases premature). "The consensus discernable from commentators, however, suggests that DNA fingerprinting will eventually be proven reliable and will revolutionize criminal law when admitted into evidence on a regular basis." Id. See Paul C. Giannelli & Edward J. Imwinkelried, Scientific Evidence § 17 (1986 & Supp. 1991). 'Genetic markers' refer to serological tests (relating to serums) of blood to determine the race and sex of the source of the blood. Id. § 17-8, at 575-76. This testing provides assistance in paternity actions. Id. Although genetics refers to the science of heredity, mapping DNA has expanded the potential for genetic marking. Id. § 17-8(E), at 603. A gene is a "functional unit of heredity which occupies a specific place or locus on a chromosome, [and] is capable of reproducing itself exactly at each cell division . . . ." Stedman's Medical Dictionary 639 (25th ed. 1990) [hereinafter Stedman's]. See generally Randolph N. Jonakait, Will Blood Tell? Genetic Markers in Criminal Cases, 31 EMORY L.J. 833, 836-43 (1982) (analyzes various blood-grouping tests and their reliability).

9 See Stedman's, supra note 9, at 304. A chromosome is "one of the bodies (normally 46 in a man) in the cell nucleus that is the bearer of the genes . . . and is capable of reproducing itself exactly at each cell division . . . ."
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living thing unique.\textsuperscript{11} Within the human body, nearly every cell carries an identical DNA configuration.\textsuperscript{12} However, except in the case of identical twins, no two individuals have matching DNA configurations.\textsuperscript{13} In forensic analysis, this phenomenon is essential for linking the DNA "print" extracted from physical evidence, such as semen,\textsuperscript{14} blood,\textsuperscript{15} hair,\textsuperscript{16} or saliva\textsuperscript{17} to a defendant's DNA.
configuration. The shape of DNA has been identified as a “double helix” structure, which resembles a twisted ladder (see diagram A). Alternating phosphate and deoxyribose sugar units comprise the sides of the ladder, while the connectors or “rungs” of the ladder are composed of pairs of “bases” (“base pairs”) known as adenine (“A”), thymine (“T”), guanine (“G”), and cytosine (“C”). Depending on its chemical composition, each base will bond only with its complement. The different sequences of the base pairs formulate each person’s genetic code. Everyone has these genetic identifiers to that in his blood, semen, and other bodily tissues). The consistency of DNA has shown that “DNA found in a man’s hair follicles at birth is identical (apart from occasional slight changes called “mutations”) to the DNA found in his blood at age seventy.”

The laboratory recommends 10,000 cells be present in the saliva sample for proper DNA isolations. Tests have shown that the sample merely needs to be a dried spot of blood about the size of a quarter, a few hairs, a dried spot of semen the size of a nickel, or a small patch of skin tissue. Criminal investigators view the testing favorably because it provides many more opportunities for linking a suspect to a crime. Along with indicating that DNA from semen taken from a rape victim matches DNA from a suspect’s blood sample, the test can determine whether a suspect’s DNA matches that of hair left at the crime scene, or from skin scraped by a victim’s fingernails.

One commentator noted that “[t]he possibility of identifying a human being by a shred of tissue or drop of blood has a strong appeal for its potential to revolutionize rape, paternity, and murder cases.” Stephen M. Patton, DNA Fingerprinting: The Castro Case, 3 HARV. J. L & TECH. 223, 223 (1990).

Complementary pairing is crucial for DNA testing because it permits scientists to locate points of differentiation in the DNA chain. See generally C. Thomas Blair, Comment, Spencer v. Commonwealth and Recent Developments in the Admissibility of DNA Fingerprint Evidence, 76 Va. L. Rev. 853, 857 (1990) (summarizing DNA typing process).
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Diagram: Restriction Fragment Length Polymorphism Analysis

- **A1**: Digest with restriction nuclease
- **A2**: Chromosomal DNA
- **B**: Double-stranded DNA fragments separated by electrophoresis through gel slab
- **C**: Fix single-stranded DNA fragments to nitrocellulose paper
- **D**: Cover paper with probe and incubate
- **E**: Position of DNA fragment complementary to labeled DNA probe

Steps:
1. Digest chromosomal DNA with restriction nuclease.
2. Separate double-stranded DNA fragments through electrophoresis.
3. Fix single-stranded DNA fragments to nitrocellulose paper.
4. Cover paper with probe and incubate.
5. Wash paper to remove unbound probe.
6. Position of DNA fragment complementary to labeled DNA probe.
netic sequences," but they vary from person to person. Advocates of DNA typing contend that these variations, also called polymorphisms, permit an individual to be identified through DNA technologies, since it is extremely unlikely that two individuals share identical polymorphisms. It is suggested that labs analyzing only a fragment of the DNA may reduce the accuracy of DNA profiling because research indicates the possibility that specific groups of individuals may exhibit identical polymorphic genes more frequently than was considered.


See Jakobetz, 955 F.2d at 791. Approximately 99% of the DNA in each individual is the same because human beings share more similarities than differences. *Id.*: Lori L. Swafford, Comment, Admissibility of DNA Genetic Profiling Evidence in Criminal Proceedings: The Case for Caution, 18 Pepper L. Rev. 123, 124-26 (1990). Human beings have more similarities than differences, thus the vast majority of base pairs do not vary from person to person. *Id.* However, there are certain sections of DNA which vary greatly among individuals. *Id.*

See Jakobetz, 955 F.2d at 791 (discussing importance of variations for identification purposes): *see also* People v. Castro, 144 Misc. 2d 956, 962, 545 N.Y.S.2d 985, 988 (Sup. Ct. Bronx County 1989) (small variation in order in which base pairs occur on DNA molecule, known as alleles, provide differences among individuals). The Castro court indicated that early uses for DNA tests involved disease detection, and that sickle-cell anemia is caused by a single base pair on a single chromosome occurring out of order. *Id.* at 963, 545 N.Y.S.2d at 989. See generally Tarantino, supra note 2, § 13.21(C), at 81 (describing significance of sequence location).

See United States v. Young, 754 F. Supp. 739, 740 (D.S.D. 1990). Although as much as 99% of the DNA in every person is identical, certain areas known as polymorphisms are distinct. *Id.* These polymorphisms are responsible for the unique DNA code of each individual. *Id.*: *see also* Swafford, supra note 23, at 126 ( undisputed distinctiveness is basis for all forms of DNA testing).

See State v. Schwartz, 447 N.W.2d 422, 424 (Minn. 1989) ("No two individuals, except for identical twins, have identical DNA."). *See also* Moss, supra note 11, at 66. Testing labs claim the DNA test establishes identity conclusively. *Id.* One lab, Cellmark Diagnostics of Germantown, Md., asserts that its "DNA fingerprint" test can identify a individual with "virtual certainty," and that the chances of any two people having the same DNA fingerprint are 1 in 30 billion. *Id.* Lifecodes claims that their research indicates that the likelihood that any two individuals, other than identical twins, having exactly the same polymorphisms in their DNA segments is extremely remote. Lifecodes, *supra* note 6, at DNA Identity Testing Pamphlet 6.

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B. Restriction Fragment Length Polymorphism Analysis—A Commonly Used Testing Method

The length of each polymorphism is determined by the number of repeat core sequences of base pairs.\(^{27}\) For example, if A-T is the specified base pair, the length of the polymorphism is the distance between the repeated A-T bonds.\(^{28}\) The Restriction Fragment Length Polymorphism ("RFLP") technique, employed by the Federal Bureau of Investigation ("FBI"),\(^{29}\) seeks to isolate the different versions of the RFLP's, also called alleles, to determine whether genetic samples from a crime scene may have come from a particular suspect.\(^{30}\)

The seven-phase RFLP process can be visualized as chemically "unzipping" the DNA ladder into two single strands of DNA, introducing genetic probes which attach to their complementary strands, and thereby locating the regions of DNA that are...
polymorphic\footnote{See, e.g., Jakobetz, 955 F.2d at 792 (outlining specific steps of RFLP analysis): see also Thompson & Ford, supra note 8, at 65 (describing purpose of RFLP test).} (see diagram A to follow steps of DNA testing). The first step in the process involves obtaining a sample of biological material, like semen, blood, or hair, and \textit{extracting} the DNA through chemical treatment and filtering.\footnote{See Young, 754 F. Supp. at 740-41 (briefly describing RFLP test): see also Perry v. State, 586 So. 2d 236, 238 (Ala. Crim. App. 1990) (stating that "[the] [DNA] test takes approximately three weeks and can be performed accurately from a single strand of hair." (citation omitted)): People v. Shi Fu Huang, 145 Misc. 2d 513, 515, 546 N.Y.S.2d 920, 921 (Nassau County Crim. Term 1989) (extraction and isolation of DNA from evidentiary sample is first step in RFLP process). See generally A.J. Jeffreys et al., \textit{Principles and Recent Advances in Human DNA Fingerprinting}, in \textit{DNA FINGERPRINTING: APPROACHES AND APPLICATIONS} I (T. Burke \textit{et al.} eds., 1991) (review of different DNA tests); LIFECODES, supra note 6, at DNA—PRINT Test sheet (providing various biological samples and amounts necessary to conduct tests).}

Next, in a process known as \textit{digestion}, an enzyme called restriction endonuclease is introduced to locate the polymorphic regions.\footnote{See Giannelli & Imwinkelried, supra note 9, § 17-8(E), at 116. The restriction endonuclease ("RE") enzymes are referred to as "biological scissors" because they cut off a section of the double stranded DNA "ladder". \textit{Id.}} The enzyme cleaves the DNA at certain recurring genetic sequences into DNA fragments.\footnote{See Young, supra note 9, § 17-8(E), at 116. In a properly conducted test, the RE cuts an individual's DNA in the same places every time and therefore produces the same fragments. \textit{Id.} Different individuals have different numbers of base pairs on the fragments cut by the RE. \textit{Id.}} The resultant DNA fragments are placed on a thin slab of gel and separated according to length.\footnote{See State v. Schwartz, 447 N.W.2d 422, 425 (Minn. 1989) (DNA chain cut at specific sites to form fragment by mixing sample with restriction enzyme): Giannelli \& Imwinkelried, supra note 9, § 17-8(E), at 116. The restriction endonuclease ("RE") enzymes are referred to as "biological scissors" because they cut off a section of the double stranded DNA "ladder". \textit{Id.}} This is accomplished by \textit{gel electrophoresis}, a procedure which applies an electric current to the gel.\footnote{See generally Thompson & Ford, supra note 8, at 69-70 (discussing process of gel electrophoresis).} Since the DNA has a negative charge, the fragments move toward the positively charged end of the gel.\footnote{See Shi Fu Huang, supra note 9, at 838-41 (defining electrophoresis as physical method for separating proteins via electric current): Thompson \& Ford, supra note 8, at 46-51 (noting development of electrophoresis technique): \textit{see also} Thomas M. Fleming, \textit{Admissibility of DNA Identification Evidence}, 84 A.L.R. 4TH 313, 352-53 (1991) (describing protein gel electrophoresis's effect on accuracy of DNA results).} The rate at which the DNA travels is
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determined by the fragment's size, length, and mass. Because the larger fragments move a shorter distance, the fragments will be arranged according to size, thereby allowing for easier comparison.

Following the denaturation or "unzipping" of the DNA into two complementary strands, the fragments are transferred to a sheet of nylon membrane in a process known as Southern Blotting, to provide a more stable medium for analysis. During the next step, hybridization, radioactive probes are introduced to locate and bond with particular sequences of the "unzipped" DNA fragments. The radioactive probes hybridize with their complementary restriction fragments on the membrane, and the lengths or sizes of the resulting bands are polymorphic, hence the term "RFLP."

The hybridized array is then exposed to an X-ray film, creating

to reach the end of the gel. Id.; see also Andrews v. State, 533 So. 2d 841, 848 (Fla. Dist. Ct. App. 1988) (negatively charged DNA moves toward positive charge).


40 See United States v. Jakobetz, 955 F.2d 786, 792 (2d Cir.) (describing Southern Blotting procedure), cert. denied, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921): State v. Pennington, 393 S.E.2d 847, 850 (N.C. 1990) (DNA moved to more permanent surface in procedure called Southern transfer). For history on the scientist after whom this phase is named, see Burley, supra note 26, at 772 (highlighting Southern Blotting).

41 See Castro, 144 Misc. 2d at 966-67, 545 N.Y.S.2d at 991. With the DNA ladder separated into a single strand, the probe will locate and bind itself to its fixed complementary strand contained on the membrane, i.e., if probe DNA sequence is ACTG, it will attach to TGAC sequence. Id. If there is no such strand, the probe will not bind with anything. Id.: see also Spencer v. Commonwealth, 384 S.E.2d 775, 782 (Va. 1989) (radioactive probe finds exact complementary base sequence and binds to that location), cert. denied, 493 U.S. 1036 (1990).

42 Interview with Mr. Steven E. Artandi, M.D.-Ph.D. candidate at the College of Physicians and Surgeons, Columbia University, in New York City, N.Y. (July 6, 1992). The authors would like to express their gratitude to Mr. Artandi for his review and comments on the scientific aspects of the article.
black bands which indicate where the radioactive probes attached to the DNA fragments. The result of this process of autoradiography resembles a grocery bar code.

Lastly, an interpretation is performed, whereby the technician either visually contrasts the patterns, or uses a computer to convert the pattern to a numerical code for comparison. The analyst will conclude that the samples' fragments correlate, that the samples do not come from the same source, or that the results are inconclusive due to sample contamination or other external influence.

C. Probabilities Estimate

When two samples are determined to be from the same source, the strength of the DNA evidence depends upon the probability that this pattern of alleles could occur randomly in a specific population group. An extremely small statistical probability may

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43 See Young, 754 F. Supp. at 741 (describing autoradiography process); State v. Schwartz, 447 N.W.2d 422, 425 (Minn. 1989) (X-ray used so DNA fragments can be seen).
44 See Cobey v. Maryland, 559 A.D.2d 391, 396 (Md. Ct. Spec. App. 1989). The probes produce dark bands on a white background, an image similar to the bar codes found on food packages in supermarkets. Id. This is known as an autoradiography or autorad. Id.; Moss, supra, note 11, at 69 (providing succinct description of steps involved in RFLP and sample processed film card); see LIFECODES, supra note 6, at DNA Identity Testing Pamphlet 11-12, Figures 3 & 4 (supplying visual exhibits of bar codes).
45 See TARANTINO. supra note 2, § 13.21(C), at 83. The author comments that following the process, the analyst compares the fragment patterns from an unknown sample—the evidence—with a known sample—the suspect's. Id. If the samples are identical, the analyst should discover the probe on fragments of the same length in the same pattern. Id. This match can be detected visually or through the use of a computer. Id. See generally Thompson & Ford, supra note 8, at 74-76 (discussing interpretation of DNA print).
46 See People v. Mohit, 579 N.Y.S.2d 990, 994 (Westchester County Ct. 1992) ("In comparing the size of the bands to each other, a match, no match, or inconclusive result is found."); see also United States v. Yee, 134 F.R.D. 161, 171 (N.D. Ohio 1991) (describing interpretation of DNA test results). While most discussion of the DNA testing focuses on the positive-identification ability, the results have been used to exculpate innocent parties. See Charles-Edward Anderson, DNA Evidence Questioned, A.B.A. J., Oct. 1989, at 18, 19 (state declined to prosecute after defendant was exculpated based on DNA results); see also Sessions, supra note 30, at 1052. When discussing the opening of the FBI's DNA lab, Commissioner Sessions stated that DNA profiling can exculpate the innocent. Id. In fact, in 1989, the Governor of Virginia granted a full pardon to a convicted murderer when DNA tests indicated that another person was responsible for the crime. Id.
47 See, e.g., People v. Castro, 144 Misc. 2d 956, 967-69, 545 N.Y.S.2d 985, 992-93 (Sup. Ct. Bronx County 1989) (discussing "Hardy-Weinberg" equilibrium which is premised on independent alleles, and its importance for "matches"); see also Gordon, supra note 1, at 25-28 (providing analysis of foundation for population genetics); Hoeffel, supra note 6, at 474 (commonness of particular DNA profile is determined after match is found). See generally M. Lynch, Analysis of Population Genetic Structure by DNA Fingerprinting, in DNA Fingerprinting 608.

overwhelm a jury considering whether the defendant was the source of the evidentiary sample. The FBI's "fixed bin" method provides a foundation for an understanding of the probabilities estimate.

This procedure involves population genetics and results in a calculation designed to determine if the match is merely a coincidence. For instance, in one case, the frequency with which the defendant's alleles were calculated to occur in the Caucasian population was one in 300 million. For DNA typing, the FBI estab
lishes "bins," based on arbitrarily defined ranges of base pair lengths, for classifying alleles. A data base of allele frequencies was developed from DNA profiles from a targeted group of FBI agents. These profiles permit a calculation for determining the frequency of occurrence for alleles falling within a particular bin. Assuming that the alleles occur randomly, the FBI multiplies the frequencies to arrive at the probability estimate for the forensic sample.

D. Population Statistics

Following location of the polymorphisms and interpretation of the bands on the DNA-print, an analyst must provide the statisti-

Id. See Jakobetz, 955 F.2d at 793 (discussing FBI's fixed bin analysis method); Giannelli & Imwinkelried, supra note 9, § 17-8(F), at 130-32 (reviewing FBI's fixed bin procedure as it relates to targeted populations); Federal Court Holds 'DNA Profile' Evidence Admissible in Criminal Trial, 59 U.S.L.W. 1059, 1059 (Oct. 16, 1990) (relating FBI's use of fixed bin genotype-frequency analysis in Jakobetz). See generally Thompson & Ford, supra note 8, at 62-66 (describing analysis of allele lengths); Laurel Beeler & William R. Wiebe, Comment, DNA Identification Tests and the Courts, 63 Wash. L. Rev. 903, 908-11 (1988) (analyzing allele fragments according to their various lengths); Norman, supra note 13, at 245-47 (applying allele lengths to various populations).

5. See Jakobetz, 955 F.2d at 793. The FBI compiles different data bases for different groups, including Caucasians, Blacks and Hispanics. Id. In this situation, the Caucasian data base was developed through blood samples from approximately 225 FBI agents. Id.

It should be noted that a data base is constructed to facilitate the inculpating aspect of DNA profiling. See Patton, supra note 17, at 228, 233-36. The author indicates that "[f]or scientific identification evidence to have exonerating power, no probabilities are necessary. If two samples exhibit non-matching characteristics, they come from two different sources." Id. at 236 (emphasis added).

6. See United States v. Jakobetz, 747 F. Supp. 250, 259 (D. Vt. 1990) (indicating bin approach assists in calculation of allele frequencies), affd, 955 F.2d 786 (2d Cir.), cert. denied, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992); see also supra note 49 (discussing FBI's fixed bin analysis). To counter challenges to probabilities estimates, the government's experts "testified that the FBI's fixed bin analysis is a very conservative estimate of allele frequency that more than compensates for potential errors that might result from limitations in technology, limited sample population data, substructure or linkage disequilibrium, and sampling error." Jakobetz, 747 F. Supp. at 259.

7. See Jakobetz, 955 F.2d at 793 (describing FBI's use of "product rule"). This "product rule" is outlined in more depth in Commonwealth v. Curnin, 565 N.E.2d 440, 444 (Mass. 1991). The product rule reflects "the probabilities of the joint occurrence of several statistically independent events." Id. In Curnin, a population geneticist expert witness raised the concern whether the probability estimates are influenced by the existence of significant substructuring (subgroups) within racial groups. Id.

8. See United States v. Young, 754 F. Supp. 759, 741-42 (D.S.D. 1990). The court recognized the potential for "band-shifting" which causes a false reading, but found the RFLP test was reliable when properly performed, and therefore the test passed both the Frye and
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cal significance of the results.\textsuperscript{67} A probability estimate is calculated by determining the frequency of the alleles within a relevant population in order to ultimately calculate the chance that the pattern from the forensic sample was from someone other than the suspect.\textsuperscript{68} Individual labs have established sample databases, one each for Caucasians, Blacks and Hispanics, to use when determining the DNA sequence frequencies within the various racial groups.\textsuperscript{69} Using the forensic sample, the lab will prepare three or four probes garnering six to eight bands for comparison purposes.\textsuperscript{60} When a match is isolated, the lab locates the frequency of its occurrence by referring to the sample database.\textsuperscript{61} An analyst, utilizing the "product rule," multiplies together each frequency garnished for

\textit{Two Bulls} standards for admissibility. \textit{Id.}; see also Thompson & Ford, supra note 8, at 87-95 (outlining potential difficulties for interpretation of prints, including print variability or "slop"). Additionally, these authors note that forensic samples are subject to abuse because the environmental conditions which the samples encounter can vary significantly and thus they are not the typical clean lab samples. \textit{Id.} at 66. Sample degradation may also affect potential readings. See Hoeffel, supra note 6, at 483 (degraded DNA samples can produce misleading bands).

The FBI combats these problems, such as band-shifting, through the use of a computer imaging process to reference the bands to molecular weight markers on the autoradiograph. See Jakobetz, 955 F.2d at 790. For additional proposals regarding standards of performance for forensic laboratories, see Randolph N. Jonakait, \textit{Forensic Science: The Need For Regulation}, 4 HARV. J. L. & TECH. 109, 166 (1991) (stating that labs need uniformity for reliable results and courts need assistance in judging scientific protocols).

\textsuperscript{67} See, e.g., Jakobetz, 747 F. Supp. at 253 (discussing frequencies needed from human population genetics). The statistical probability can be considered as follows: With the assertion that the chance of a random match is 1 in 30 million, 30 million people would need to be tested before a match would occur by chance. See Kelly, supra note 10, at 109. For those mathematically inclined who desire a more in-depth view of population genetics than discussed in this Note, see Lynch, supra note 47, at 113 (emphasizing limitations in multilocus DNA fingerprinting studies).

\textsuperscript{68} See United States v. Yee, 134 F.R.D. 161, 171 (N.D. Ohio 1991) (FBI developed table of allele frequencies, applied sample being tested to this table, and multiplied frequencies using product rule to arrive at probability estimate); \textit{Curnin}, 565 N.E.2d at 443 (Cellmark determines allele by allele its frequency in population in its data base); People v. Castro, 144 Misc. 2d 956, 967-69, 545 N.Y.S.2d 985, 992-93 (Sup. Ct. Bronx County 1989) (population geneticists identify specific allele frequencies).

\textsuperscript{69} See, e.g., People v. Mohit, 579 N.Y.S.2d 990, 991 (Westchester County Ct. 1992) (FBI lab provided probability estimates for Caucasian, Black, and Hispanic populations); People v. Wesley, 140 Misc. 2d 306, 327, 533 N.Y.S.2d 643, 656 (Albany County Ct. 1988) (discussing DNA groupings); see also GIANNELLI & IMWINKELRIED, supra note 9, § 17-8(E), at 129 (noting that data bases are limited, with Lifecodes's including 2,400 individuals and Cellmark's 10,000 individuals).

\textsuperscript{60} See Thompson & Ford, supra note 8, at 84 (discussing procedure for calculating probability estimate).

\textsuperscript{61} \textit{Id.}
each matching band; these frequencies represent the alleles. The validity of this multiplication procedure assumes that each variable included occurs randomly and independently of the others. However, the reliability of this procedure has been challenged by population geneticists claiming that alleles do not occur as independently as previously assumed.

Population genetics posits that for the alleles to occur randomly, they must not be caused by “linkage disequilibrium,” and the relevant racial population must be in the “Hardy-Weinberg equilibrium.” Linkage disequilibrium can affect the physical proximity of bands on DNA segments. Population geneticists believe that if portions of one person’s alleles are identical to those of another person, it is possible for other identical sets of alleles to link up, resulting in longer pieces of identical DNA in two people. If an analyst tested these portions of the strand, a mistakenly positive identification would follow. However, labs

See id. The “product rule” provides as follows: If one band of a match corresponds with an allele found in ten percent of the population and the other allele represents that found in fifty percent of the population, the probability of a coincidental match on both alleles is 0.10 x 0.50 = 0.05, or a five percent probability. See id. at 81-82. See generally Gianelli & Imwinkelried, supra note 9, § 17-9(A), at 607-09. (reviewing population frequencies).

See Wesley, 140 Misc. 2d at 327, 533 N.Y.S.2d at 656 (describing random and independent conditions needed to ensure appropriate probability determination).

See Richard C. Lewontin & Daniel L. Hartl, Population Genetics in a Forensic DNA Typing, 254 Science 1745, 1746 (1991). The authors suggest the need for “subpopulation studies already carried out for blood groups and enzymes.” Id. at 1750; see also Gianelli & Imwinkelried, supra note 9, § 17-8(E), at 128-30 (inquiring into existence of subpopulations and effect on estimates); Brownlee, supra note 6, at 60-61 (noting challenges to population statistics).

See Hoeffel, supra note 6, at 491 (suggesting laboratory methods to avoid linkage disequilibrium, nonindependent inheritance of alleles caused by close proximity); Thompson & Ford, supra note 8, at 85-86 (defining linkage disequilibrium as nonindependence of bands in DNA prints caused by physical closeness of DNA segments).

See People v. Castro, 144 Misc. 2d 956, 968, 545 N.Y.S.2d 985, 992 (Sup. Ct. Bronx County 1989) (indicating allele frequencies must be independent from generation to generation).

See Thompson & Ford, supra note 8, at 85; see also Dirusso, supra note 50, at 211 (discussing “Hardy-Weinberg equilibrium” as set forth in Castro).

See Lewontin & Hartl, supra note 64, at 1745-46. The authors indicate that a reduction in “linkage disequilibrium” would cause a particular sequence to be more prevalent in a certain population, thereby limiting the effectiveness of the probability calculation. Id. at 1747; see also Hoeffel, supra note 6, at 490-92 (discussing linkage equilibrium’s effect on probability estimate); Thompson & Ford, supra note 8, at 84-87 (nonindependence associated with linkage disequilibrium).

See Hoeffel, supra note 6, at 491-92 (describing Lifecodes’s declaration of match that
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have diminished this problem by using probes that recognize widely separated loci.\(^7\)

The Hardy-Weinberg equilibrium provides a formula for determining population statistics, premised upon a freely mixing population, to ensure an equal distribution of alleles within the groups.\(^7\) Critics argue that the existence of subpopulations, i.e., breeding within groups from different racial, religious, or geographic backgrounds, calls for the rejection of the current probabilities estimate.\(^7\) Subgroup breeding will cause higher rates of identical DNA fragments, thereby skewing the results from the product rule calculation.\(^7\) Because these subgroups exist, population geneticists maintain that the use of one database for all Caucasians and the use of the product rule to determine an allele's frequency is improper.\(^7\) Furthermore, critics contend that the probabilities of matches among people's DNA fragment sequences\(^7\) are much fewer than proposed by labs because random mixing is less frequent in subgroups, due to the fact that populations tend to engage in "endogamy," or marry within one's encountered dispute); Thompson & Ford, supra note 8, at 81-86 (steps for determining match and associated problems).\(^7\) See Thompson & Ford, supra note 8, at 85-86 (discussing recent use of multiple probes).

\(^1\) See United States v. Yee, 134 F.R.D. 161, 173 (N.D. Ohio 1991) (adopting FBI procedures for DNA tests). U.S. Magistrate Judge James Carr included in his report the distinction between DNA profiles which are homozygotes (polymorphic form of VNTR produces one band) and heterozygotes (polymorphic form of VNTR produces two bands) as well as the FBI's attempt to use a conservative calculation. Id. at 172-73; see also People v. Castro, 144 Misc. 2d 956, 968-69, 545 N.Y.S.2d 985, 992-93 (Sup. Ct. Bronx County 1989) (utilizing frequency multipication formula). See generally Hoeffel, supra note 6, at 489-92 (reviewing and challenging Hardy-Weinberg assumption).

\(^2\) See Lewontin & Hartl, supra note 64, at 1749-50 (challenging reliability of probability estimates due to labs' failure to consider subpopulations).

\(^3\) See id. Lewontin and Hartl contend that the use of statistical tests for the Hardy-Weinberg equilibrium is misplaced as a means to look for genetic differentiation between subgroups in a population. Id. at 1747. See generally Gordon, supra note 1, at 25-27 (providing history for Hardy-Weinberg and relevancy to population statistics).

\(^4\) See United States v. Jakobetz, 747 F. Supp. 250, 260 (D. Vt. 1990) (describing perceived flaws in probability estimates), aff'd, 955 F.2d 786 (2d Cir.), cert. denied, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992); see also Harlan A. Levy, DNA: Race, Ethnicity and Statistical Evidence, N.Y.L.J., July 15, 1991, at 1 (critics maintain population statistics based on broad population groupings are useless since there are racial and ethnic subgroups [the technical term used is "substructures"] within the Caucasian, African-American and Hispanic populations).

\(^5\) See supra notes 27-30 and accompanying text (identifying VNTR, core sequence pattern of fragment length, and how it relates to DNA profiling).
group. Additionally, critics maintain that the estimates may be misleading by "two or more orders of magnitude" because they ignore the existence of subgroups, thereby reducing the probability of identification to less determinative numbers. Therefore, they suggest that the estimates be excluded from courtrooms until proper subpopulation studies can be performed.

Contrary to this claim, supporters of DNA typing stress that the probabilities are "valid estimates" and possible errors will more frequently balance out than strengthen the estimate. Additionally, two scientists reported that a five-locus DNA profile would have a "vanishingly small" probability of a match, even when accounting for subpopulations. In response to this dispute, the FBI will examine additional DNA databases of ethnic subgroups, while others call for a national DNA database similar to that for fingerprints.

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76 See United States v. Yee, 134 F.R.D. 161, 181-82, 184-85 (N.D. Ohio 1991) (testimony involving effect of endogamy); see also Lewontin & Hartl, supra note 64, at 1747-48 (criticizing use of estimates without proper research).

77 Lewontin & Hartl, supra note 64, at 1749. The census designation "Hispanic" is a biological hodgepodge including Mexicans, Puerto Ricans, Guatemalans, Cubans, Spanish and others. Id. See generally John Brookfield, Law and Probabilities, 355 Nature 207, 207-08 (1992) (analyzing dispute in authority regarding population probabilities).

78 See Yee, 134 F.R.D. at 182 (expert witness noting that using FBI's databases would not enable him to make accurate probability statement); see also Lewontin & Hartl, supra note 64, at 1750 (current calculations unjustified and generally unreliable).

79 Ranajit Chakraborty & Kenneth K. Kidd, The Utility of DNA Typing in Forensic Work, 254 Science 1735, 1738 (1991). Dr. Kidd claims that the effect of subpopulations is minimal, noting "[i]t makes absolutely no difference . . . if the number is 1 in 800,000 or 1 in 5 million." Id.; see Leslie Roberts, Fight Erupts over DNA Fingerprinting, 254 Science 1721, 1721 (1991). Dr. Kidd also indicates that "it probably doesn't matter to a jury either." Id.


81 See Christopher Anderson, DNA Fingerprinting—FBI Gives In On Genetics, 355 Nature 663 (1992). Announcing that the FBI will undertake investigation of additional subpopulations, John Hicks, the assistant director of the FBI's laboratory division stated, "we want to see if there is any great divergence from the kind of distribution of [DNA] alleles we see in the United States. We've assumed that there isn't." Id.

82 See Gianelli & Imwinkelried, supra note 9, § 17-8(E), at 131 (indicating several states mandate all newly convicted felons such as sex offenders to supply samples for DNA databases (citation omitted)). See generally Jones v. Murray, 765 F. Supp. 842, 851 (W.D. Va. 1991) (upholding constitutionality of Virginia statute directing creation of DNA database of convicted felons); Joanne Marie Longobardi, DNA Fingerprinting and the Need For a National Data Base, 17 Fordham Urb. L.J. 323, 350-57 (1989) (discussing privacy issues and supporting formation of national DNA database).
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The reliability of the probabilities estimate portion of the DNA profiling test has received a mixed response in the courtroom. Population geneticists who challenged this test served to amplify concerns by some courts considering the admissibility of this scientific evidence. Of primary concern is whether a minuscule probability estimate would have an unduly prejudicial effect on a jury’s decision-making. For instance, a finding that the likeli-

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83 See Lewontin & Hartl, supra note 64, at 1745 (questioning assumptions underlying population groups). The authors maintain that forensic scientists ignore considerable evidence indicating genetic substructure within ethnic populations. Id. at 1746. Further, they assert “[a]s currently calculated, the estimates may be in error, possibly by two or more orders of magnitude.” Id. at 1749; see also Brownlee, supra note 6, at 60 (remarking on prejudicial dangers including falsely implicating suspects). See generally Harlan A. Levy, DNA Evidence in Criminal Cases: Legal Developments, N.Y.L.J., Apr. 25, 1990, at 1 (anticipating population statistic controversy).

84 See, e.g., State v. Pennell, 584 A.2d 513 (Del. Super. Ct. 1989). In Pennell, the court considered the defendant’s motion in limine to excluded DNA evidence. Id. at 514. Applying the more relaxed Uniform Rules of Evidence standard rather than the Frye approach, Judge Gebelein limited the DNA evidence by excluding the statistical probabilities. Id. at 519-20. The court noted the probabilities were not reliable, and prejudicial dangers outweighed the probative value of approximate figures derived from calculations based on population not proven to be in Hardy-Weinberg equilibrium and not corrected in a scientifically accepted way. Id. at 519-20; cf. Martinez v. State, 549 So. 2d 694 (Fla. Dist. Ct. App. 1989). In Martinez, the defendant argued that the expert’s testimony concerning the probabilities was so overwhelming that it would interfere with the jury’s fact-finding function. Id. Finding the mathematical theory for DNA akin to traditional fingerprint evidence, Judge Sharp rejected the defendant’s approach and admitted the evidence based on its relevancy and probativeness. Id. at 697. Determining the statistical probability to be reliable and admissible, the court indicated that statistical evidence does not prevent the jury from considering the issue of identity because the jury may choose to disbelieve expert witness testimony. Id. See generally Caroline M. Kelly, Comment, Admissibility of DNA Evidence: Perfecting the “Search for Truth,” 25 Wake Forest L. Rev. 591, 615-16 (1990) (advocating strict standard for admissibility and standardization of testing procedures).

85 See United States v. Jakobetz, 955 F.2d 786, 789 (2d Cir.), cert. denied, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921). The court recognized how “devastating” the probability estimate can be, noting that: “the results of such testing can be so dramatic as to become virtually dispositive on the question of identity, which often determines a defendant’s guilt or innocence.” Id. The Jakobetz court eventually affirmed the defendant’s conviction because it believed that a jury was capable of remaining impartial before being convinced by the totality of the evidence presented. Id. at 792-93.

The use of the estimate gives the appearance of certainty and reliability which may sway a juror. See Moss, supra note 11, at 70. Edward Blake of Forensic Science Associates, which uses polymerase chain reaction (PCR) analysis, not RFLP testing, claims he expects DNA typing to become widely used—to the extent that the jury will have little to decide. Id. This type of undue reliance on the estimates persuaded some commentators to advocate the more stringent admissibility requirements. See, e.g., Edward J. Imwinkelried, The Debate in the DNA Cases Over the Foundation for the Admission of Scientific Evidence: The Importance of Human Error as a Cause of Forensic Misanalysis, 69 Wash. U. L.Q. 19, 46 (1991) (recommending heightened standard of admissibility for scientific evidence).
hood of a specific DNA print randomly occurring in the population is one in 234 billion appears conclusive, especially in light of the fact the earth's population is approximately five billion. Further, the jury may be swayed by these high probabilities that may not be accurate due to ignored subgroups and the practice of fractional testing.

II. LEGAL STANDARDS FOR ADMISSIBILITY

A. Frye v. United States

The landmark case regarding the admissibility of novel scientific evidence is Frye v. United States. In Frye, the United States Court of Appeals for the District of Columbia held that before evidence deduced from a scientific principle or discovery is admissible, such scientific principle or discovery must have gained "general acceptance in the particular field in which it belongs." Although Frye cited neither precedent nor authority, its "general acceptance" standard was adopted by a large majority of state and federal jurisdictions. The Frye case itself dealt with a systolic

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86 See Martinez, 549 So. 2d at 695, 697 (rejecting defendant's challenge that probability estimate was unduly prejudicial, but noting that defense counsel failed to refute underlying scientific basis of test or Hardy-Weinberg equilibrium formula).

An opponent of the estimate figures insisted that a jury cannot prevent being overwhelmed "[w]hen an expert comes in and says there's a one in 700 million chance that your man is not the one—and you know he's only one of 30 million black men in the country—it just kills you. It intimidates the jury." Gary Taylor, From One Speck, A Case Is Made, NAT'L L.J., Jan. 16, 1989, at 3.

87 See supra notes 64 & 72 and accompanying text (discussing fractional DNA testing and subgrouping's reducing accuracy of DNA profiling).

88 293 F. 1013 (D.C. Cir. 1923).

89 Id. at 1014 (emphasis added).

90 See United States v. Jakobetz, 955 F.2d 786, 794 (2d Cir.) (majority of jurisdictions which faced similar issues adopted Frye test, and it remains majority rule), cert. denied, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921); CARLSON. supra note 1, at 220 (for most jurisdictions, Frye still respected precedent); Hoeffel, supra note 6, at 496 (confirming majority of jurisdictions accept Frye standard).

For federal decisions applying Frye, see, e.g., United States v. Distler, 671 F.2d 954, 961 (6th Cir.) (utilizing Frye as operative standard), cert. denied, 454 U.S. 827 (1981); United States v. Tranowski, 659 F.2d 750, 756 (7th Cir. 1981) (rejecting evidence as not having gained general acceptance in its field); United States v. Hendershot, 614 F.2d 648, 654 (9th Cir. 1978) (rejecting contention that technology for lifting shoe prints was not generally accepted by crime lab technicians).
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blood pressure deception test, an early version of the lie detector. The standard it advocated has since been applied to a wealth of scientific and technical advances. Many such advances, including polygraphy and voice spectrography, have been excluded from evidence for failure to meet the “general acceptability” standard.

For state cases applying Frye, see, e.g., State ex rel. Collins v. Superior Court, 644 P.2d 1266, 1285 (Ariz. 1982) (Frye applicable to hypnotically induced recall testimony); People v. Gonzales, 329 N.W.2d 745, 745 (Mich. 1982) (declaring Frye is applicable test in Michigan courts); Commonwealth v. Topa, 369 A.2d 1277, 1281 (Pa. 1977) (spectrographic analysis not sufficiently accepted by scientific community to satisfy Frye). See generally Gianelli & Imwinkelried. supra note 9, § 1-5, at nn.42-55 (listing state and federal cases that have adopted Frye as governing test).

See Frye, 293 F. at 1014 (utterance of falsehood requires conscious effort which is reflected in blood pressure).

See McCormick. supra note 5, § 203, at 869-70. Polygraphy, graphology, hypnotic and drug induced testimony, voice stress analysis, voice spectrograms, ion microprobe mass spectroscopy, infrared sensing of aircraft, retesting of breath samples for alcohol content, psychological profiles of battered women, and child abusers, post-traumatic stress disorder as indicating rape, astronomical calculations, and blood group typing, all have fallen prey to . . . [Frye’s] influence.

Id. at 606 (footnotes omitted); see also United States v. Brown, 557 F.2d 541, 557 (6th Cir. 1977) (ion microprobe analysis for hair comparisons excluded because not generally accepted). See generally Carlson, supra note 1, at 237-41 (setting forth admissibility of scientific evidence per Frye); Gianelli & Imwinkelried. supra note 9, § 1-5(A-D) at 15-25 (discussing Frye standard for admissibility of expert testimony on scientific evidence).

See Gianelli & Imwinkelried. supra note 9, § 8-2, at 232-48. The authors discuss the commonly accepted theory underlying polygraphy that when a person being examined fears detection, his deceptive response produces measurable physiological reaction. Id. The physiological responses examined include changes in blood pressure, pulse, respiration and galvanic skin resistance. Id.

See id. § 10-2, at 310-18. Voice spectrography involves a speech sample entered into a device called a spectrograph, which converts sounds into a visual display known as a spectrogram. Id. at 312. An examiner may then compare different spectrograms to determine if they were made by the same speaker. Id.

See, e.g., Brown v. Darcey, 783 F.2d 1389, 1391, 1394-97 (9th Cir. 1986) (excluding polygraphic evidence from trial for failure to meet Frye); United States v. Alexander, 526 F.2d 161, 166 (8th Cir. 1975) (same). For cases excluding spectrography evidence, see United States v. McDaniel, 538 F.2d 408, 413 (D.C. Cir. 1976) (finding spectrographic evidence inadmissible because not generally accepted); United States v. Addison, 498 F.2d 741, 745 (D.C. Cir. 1974) (excluding expert testimony of spectrographic voice analysis because not generally accepted). See generally McCormick, supra note 5, §§ 206(B), 207, at 907-35 (discussing exclusion of polygraphy and voice spectrography from evidence under Frye and other standards of admissibility). But see United States v. Smith, 869 F.2d 348, 351 (1989) (allowing admissibility of spectrographic voice identification); McMorris v. Israel, 643 F.2d 458, 462 nn.9-11 (7th Cir. 1981) (admitting polygraph results into evidence at trial), cert. denied, 455 U.S. 967 (1982); United States v. Webster, 639 F.2d 174, 186 (4th Cir.) (upholding exclusion but noting that district judge had discretion to admit polygraph evidence), cert. denied, 454 U.S. 857 (1981); United States v. Williams, 583 F.2d 1194,
In recent years, the *Frye* standard has come under attack by courts and commentators alike, who have expressed dissatisfaction with its ability to adequately determine the admissibility of many modern techniques. DNA profiling is one such technique. The United States Court of Appeals for the Second and Eighth Circuits have been the only two federal appellate courts to address this issue. Neither court expressed wholehearted acceptance of the *Frye* standard; rather each enumerated what was perceived as a more viable solution to the evidentiary problem. The Eighth


96 See United States v. Jakobetz, 955 F.2d 786, 794 (2d Cir.), cert. denied, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921). "[T]he *Frye* test . . . has been attacked for its overly conservative approach to admissibility and its susceptibility to manipulation in order to exclude novel scientific evidence." Id.; Giannelli, supra note 1, at 1250. "The *Frye* test, which has cast its shadow over the admissibility of scientific evidence for more than a half-century, has proved unworkable." Id. Professor Giannelli includes in his criticism of *Frye* the difficulty in identifying the proper scientific field. Id. at 1208. Also, although courts do not require unanimous acceptance, there is a broad range of what may constitute "general" acceptance. Id. at 1210. Further, *Frye* may cause a "cultural lag" where it will take a long time for even properly admissible techniques to be caught up with in the scientific community. Id. at 1223; Mark McCormick, *Scientific Evidence: Defining a New Approach to Admissibility*, 67 IOWA L. REV. 879, 883 (1982) (*Frye* standard has been criticized, limited, modified, and faces increasing rejection). McCormick further states that the adoption of new rules of evidence has caused critical examination of the *Frye* standard. Id. at 887; see also Williams, 583 F.2d at 1198 ("determination of reliability cannot rest solely on a process of 'counting (scientific) noses'"); United States v. Baller, 519 F.2d 463, 466 (4th Cir.) (without expressly rejecting *Frye*, applied relevancy analysis), cert. denied, 423 U.S. 1019 (1975); Joseph G. Petrosinelli, Note, *The Admissibility of DNA Typing: A New Methodology*, 79 GEO. L.J. 313, 317-18 (1990). "The general and imprecise language of the *Frye* test has generated debate over the test's actual requirements." Id. at 318. Four concerns have been raised, namely, what is general acceptance, what is capable of general acceptance, who determines the reliability of the evidence, and when the test is applied. Id.


98 See Jakobetz, 955 F.2d at 795 (noting that Eighth Circuit was only other federal circuit court to address issue).

99 See id. at 794 (holding *Frye* standard had previously been superseded by Federal Rules of Evidence); United States v. Two Bulls, 918 F.2d 56, 60 (8th Cir. 1990) (court must satisfy itself that sufficient foundational basis exists before admitting DNA evidence which is potentially unduly prejudicial to defendant); infra notes 102-125 and accompanying text (describing DNA admissibility standards used by courts).
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Circuit adopted Frye but added an additional restriction to admissibility. The Second Circuit embraced an approach less restrictive than the Frye test and, therefore, was more receptive to DNA profiling evidence.

B. Eighth Circuit: United States v. Two Bulls

In United States v. Two Bulls, the court, in an opinion by Chief Judge Lay, adopted the same standard proposed in People v. Castro, which advocated an admissibility test more stringent than the Frye test. The Castro approach requires a three-prong examination of novel scientific evidence to determine admissibility. Applying this test to DNA profiling, the courts must first determine whether there is a generally accepted theory in the scientific community which finds DNA testing results reliable. Second, it must decide if there are techniques, generally accepted in the scientific community, that are capable of producing reliable results in DNA identification. These first two elements are essentially the equivalent of the Frye test. However, the Castro and Two

100 See Two Bulls, 918 F.2d at 60 (mandatory pretrial hearing held to determine whether particular laboratory which performed test used accepted techniques).
101 See Jakobetz, 955 F.2d at 794 (in attacking Frye for its overly conservative approach, court adopted Federal Rules of Evidence approach which is more permissive in determining admissibility).
102 918 F.2d 56 (8th Cir. 1990). In Two Bulls, a 14-year-old girl was raped on an Indian Reservation in South Dakota. Id. at 57. The semen stain found on the victim's underwear was tested against a sample of blood taken from the defendant, Two Bulls, and indicated a match. Id. Based on Native American population figures, experts testified that the statistical probability that the stain could have come from someone other than Two Bulls was 1 in 177,000. Id. at n.2. The United States Court of Appeals for the Eighth Circuit held that the standard for admissibility used at trial was improper, vacated the conviction, and remanded the case. Id. at 61. The court found that the propriety of the lab's testing procedures must be considered in determining the admissibility of the DNA evidence. Id.
103 144 Misc. 2d 956, 545 N.Y.S.2d 985 (Sup. Ct. Bronx County 1989); see Two Bulls, 918 F.2d at 60 (court accepted three-prong test put forth in Castro).
104 Castro, 144 Misc. 2d at 960, 545 N.Y.S.2d at 987.
105 Id. at 959, 545 N.Y.S.2d at 987; see United States v. Medina, 749 F. Supp. 59, 62 (E.D.N.Y. 1990) (in admitting novel scientific evidence, court should determine that same was obtained properly, laboratory technique was sound, and laboratory was accurate in use of technique); United States v. Young, 745 F. Supp. 739, 741 (D.S.D. 1990) (utilizing test incorporating three prongs of Castro); infra notes 106-109 and accompanying text (outlining Castro test).
106 Castro, 144 Misc. 2d at 959, 545 N.Y.S.2d at 987.
107 Id.
108 Compare Castro, 144 Misc. 2d at 960, 545 N.Y.S.2d at 987 with United States v. Frye,
Bulls courts imposed an additional burden on the proponent of DNA evidence in a criminal case.\textsuperscript{109} This third element requires the court to determine whether the testing lab properly performed the accepted scientific techniques in analyzing the DNA samples in the particular case.\textsuperscript{110} The \textit{Two Bulls} court explained that its test is applicable to other types of novel scientific evidence as well.\textsuperscript{111}

\textbf{C. Second Circuit: United States v. Jakobetz}

In \textit{United States v. Jakobetz},\textsuperscript{112} the Second Circuit defined the guidelines for determining the admissibility of DNA profiling evidence.\textsuperscript{113} In an opinion by Judge Pratt, the court relied heavily on standards implicit in the Federal Rules of Evidence.\textsuperscript{114} In particular, the court suggested that the "balancing test" enumerated in Rule 403, which excludes evidence when its probative value is substantially outweighed by the danger of unfair prejudice,\textsuperscript{115} coupled with Rule 702, which allows for the testimony of expert wit-
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nesses. This "relevancy" analysis provides that conclusions which are supported by expert witness testimony should be admitted into evidence unless the danger of unfairly prejudicing or misleading the jury exists. This test relies on the premise that the Federal Rules of Evidence supersede the Frye test, as was found in United States v. Williams.

In Williams, Chief Judge Markey suggested that the probative-ness, materiality and reliability of evidence must outweigh any tendency it may have to mislead, prejudice or confuse a jury. The Williams court went on to enumerate five suggested determinants of reliability: the potential rate of error, the existence and maintenance of standard testing procedures, the care and concern with which the technique has been employed, the ability to analogize evidence in question to other forms of evidence which are generally admitted, and the demonstration of the test's failsafe characteristics. Once these factors are satisfied, the court may

116 Fed. R. Evid. 702. This rule provides that: "[i]f scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise." Id.


118 See McCormick, supra note 5, § 203, at 875 (relevant conclusions should be admitted absent clear reasons for exclusion); cf. Black, supra note 1, at 597. To alleviate the difficulty surrounding the admissibility of scientific evidence, the author proposes a two-pronged relevancy test. Id. First, the validity of the reasoning of a conclusion and next, the reliability of that conclusion. Id.; Dale A. Nance, Conditional Relevance Reinterpreted, 70 B.U. L. Rev. 447, 447 (1990). The admissibility of "every piece of evidence offered" hinges on its relevancy. Id. See generally Fed. R. Evid. 401. This rule provides that: "[r]elevant evidence means evidence having any tendency to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence." Id.

119 See McCormick, supra note 5, at 608 (general acceptance in community not suitable for determining admissibility of novel scientific evidence); Petrosinelli, supra note 96, at 322 (stating that proponents of relevancy test argue that Federal Rules supersede Frye). Some jurisdictions have applied a modified relevancy analysis. See, e.g., United States v. Downing, 753 F.2d 1224, 1225 (5th Cir. 1985) (Federal Rules of Evidence neither incorporate nor repudiate Frye); see also Petrosinelli, supra note 96, at 323 (many of same inquiries would be made under Frye and modified relevancy test).

120 583 F.2d 1194 (2d Cir. 1978). The Williams court discussed standards in determining reliability with respect to spectrography. Id. at 1198.

121 Id. at 1198.

122 Id. at 1198-99.
properly apply the test which "boils down to a balancing of the reliability of the evidence against its potential negative impact on the jury." Although Williams did not deal specifically with DNA evidence, the Jakobetz court adopted its rationale as applying to all forms of novel scientific evidence.

III. PROPER SCIENTIFIC PROTOCOL: WEIGHT OR ADMISSIBILITY?

Should a determination of whether proper scientific protocol was followed in the testing procedures be one of weight for the jury, or one of admissibility for the court? The Two Bulls court concluded that a showing of proper scientific protocol was a prerequisite to the admissibility of scientific evidence. In support of its position, the Eighth Circuit advanced the theory that there is an increased possibility of unfair prejudice to a criminal defendant if the determination is left to the jury, since it has been argued that jurors tend to give unwarranted weight to hypertechnical scientific testimony that is outside the realm of their understanding.

Another argument in favor of the position taken by the Two Bulls court is that for all scientific evidence, a proper foundation

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124 Williams, 583 F.2d at 1196. The scientific evidence involved in Williams was spectrographic voice analysis. Id.
125 Jakobetz, 955 F.2d at 796.
126 United States v. Two Bulls, 918 F.2d 56, 59 (8th Cir. 1990). "[P]assing 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 59 (citing People v. Castro, 144 Misc. 2d 956, 960, 545 N.Y.S.2d 985, 987 (Sup. Ct. Bronx County 1989)).
127 Id. at 61; see Jakobetz, 955 F.2d at 796 (defendant insisted that jury was unable to independently scrutinize DNA evidence in light of complicated expert testimony and urged that an "aura of mystic infallibility" surrounding evidence led jury to abdicate its fact-finding function, prejudicing his defense). This argument finds further support in the cases and commentaries on this subject. See United States v. Baller, 519 F.2d 463, 466 (4th Cir.) (apparent objectivity of scientific testimony may cause jury to give it undue weight), cert. denied, 423 U.S. 1019 (1975); United States v. Addison, 498 F.2d 741, 744 (D.C. Cir. 1974). "[S]cientific proof may in some instances assume a posture of mystic infallibility in the eyes of a jury of laymen . . . ." Id. at 744; GIANNELLI & IMWINKELRIED, supra note 9, § 1-6(B), at 33 (principal danger of scientific evidence is its potential to mislead); Hoeffel, supra note 6, at 511. Jurors are not likely to second guess the opinions of experts testifying about DNA test results. Id. Also, jurors in early DNA cases "were in no position to reject evidence as exciting and as intimidating as DNA typing." Id. at 515.
must be laid before it can be admitted. The Eighth Circuit held that the necessary foundation included a demonstration that proper scientific protocol was followed in each particular case. Such a showing should be made at a pre-trial hearing to determine whether or not the jury will be allowed to use the evidence in drawing its conclusions.

However, in the Second Circuit, the Jakobetz court believed that whether proper scientific protocol was followed is a determination to be made by the trier of fact, generally the jury. The court found that DNA evidence should not require its own special standard of admissibility and argued that determining whether or not the test was properly conducted was clearly within the province of the jury. Proponents of the relevancy test for determining the admissibility of novel scientific evidence provide support for the Second Circuit’s arguments since they believe that all relevant evidence should be admitted absent a clear reason for excluding it. Additionally, as noted in United States v. Williams, sufficient inherent procedural safeguards exist to warrant allowing such testimony to reach the jury. The credibility of the expert, the accu-

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188 See Two Bulls, 918 F.2d at 60 (proper foundation must be laid for all scientific tests and lab procedures).

189 Id. at 60. "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." Id. The court further stated that for other types of scientific evidence, including polygraph and blood tests, such a stringent foundational requirement, a showing that correct procedures were followed, has been necessary. Id. (citing Sprynczatyk v. General Motors Corp., 771 F.2d 1112, 1122-24 (8th Cir. 1985), cert. denied, 475 U.S. 1046 (1986); see United States v. Alexander, 526 F.2d 161, 163-64 (8th Cir. 1975) (refusing to admit polygraph test where procedures not generally accepted); see also State v. Schwartz, 447 N.W.2d 422, 426 (Minn. 1989) (DNA test results only as reliable and accurate as testing procedures used by particular laboratory); Imwinkelried, supra note 85, at 28-29 (use of proper test protocol should be prerequisite to admitting scientific evidence).

190 Two Bulls, 918 F.2d at 60.


192 Jakobetz, 955 F.2d at 796.

193 See McCormick, supra note 5, § 203, at 875 (contending jury should consider all relevant evidence); 3 Jack B. Weinstein & Margaret A. Berger, Weinstein's Evidence § 702[03], at 702-30 (1991) (jury intelligent enough, with assistance of counsel, to consider only helpful evidence).

racy and reliability of his equipment and the technique itself are all subject to challenge and attack on cross-examination and through the testimony of opposing experts. Also, the jury can be instructed that, should it find the testimony unreliable, it may reject it.

Furthermore, rather than proving to the judge prior to the trial that the proper scientific protocol was followed, as was done in the Eighth Circuit, the Jakobetz court favored a more relaxed approach to the foundation question. The court stated that scientific data should be admitted only upon a preliminary showing of reliability. Such a showing might include evidence of how the lab work was conducted and what analysis and assumptions underlie the probability calculations. The court found that affidavits regarding the testing procedures used would generally be considered a sufficient foundational basis for admitting DNA profiling evidence. The fact that only a preliminary showing was necessary is consistent with the policies underlying the relevancy test advocated in Williams and would allow a jury to retain its fact-finding function.

IV. The Future of DNA Profiling

In determining the standard for admitting DNA profiling evidence, the Eighth and Second Circuits have advocated comprehensive, yet disparate, approaches. Such inconsistent authority

138 Id.
139 Id.
137 United States v. Two Bulls, 918 F.2d 56, 59 (8th Cir. 1990); see supra notes 126-130 and accompanying text (outlining Eighth Circuit’s holding regarding laying foundation for evidence).
138 See Jakobetz, 955 F.2d at 800 (factual determination should rarely be excluded from jury).
136 Id.
140 Id.
141 Id.
142 Williams, 583 F.2d at 1198 (Williams dealt with question of determining admissibility, not with truth or falsity of scientific “fact” or “truth”): see McCormick, supra note 5, § 203, at 876. “[T]he rigor of the requisite foundation can be adjusted to suit the nature of the evidence and the context in which it is offered.” Id. (footnotes omitted); supra notes 120-123 and accompanying text (discussing Williams’s reliability analysis).
143 See Jakobetz, 955 F.2d at 800 (jury must retain fact-finding function despite difficulties in weighing confusing evidence).
144 See supra notes 102-125 and accompanying text (discussing approaches taken in
DNA Identification

will necessarily cause federal and state courts facing this issue in the future to adopt either the relevancy test employed in *Jakobetz*, the three-prong analysis favored by *Two Bulls*, or, it is suggested, a different approach likely to combine elements of each.

Recently, in *People v. Mohit*, the Second Judicial Department of New York was called upon to address the admissibility of DNA evidence. There, the court relied on the general acceptability standard of the *Frye* test. The primary focus was whether probability estimates should be considered as a matter of admissibility for the court, or allowed into evidence upon only a preliminary showing to the judge, to be weighed by the jury later. The *Mohit* court held that whether or not the probability estimates were proper was an issue of admissibility. In arriving at its decision, the court rejected the Second Circuit's decision in *Jakobetz* to allow the jury to weigh the propriety of the probability estimates. The *Mohit* court explained that this issue was in part demonstrative of the overall general acceptability, and therefore, an admissibility issue. The *Mohit* court expressly rejected the third prong of the *Two Bulls* analysis, by declaring that whether or not the experiment was properly conducted should be an issue of

Eighth and Second Circuits).

*Jakobetz*, 955 F.2d at 796-97; see *supra* notes 112-125 and accompanying text (discussing approach taken in Second Circuit).

*Two Bulls*, 918 F.2d at 60; see *supra* notes 102-111 and accompanying text (discussing approach taken in Eighth Circuit).


Id. at 991. The defendant, Dr. Mohit, was indicted for raping and sexually abusing a patient during an office examination. Id. Semen was recovered from a vaginal swab of the victim and was tested along with the defendant's blood to determine the possibility of matching DNA characteristics. Id. A match was declared, and it was held that "the probability of such a match occurring in the United States was 1 in 67,000,000 for Caucasians, 1 in 79,000,000 for Blacks, and 1 in 14,000,000 for Hispanics." Id. The court held that the DNA evidence was admissible, yet it limited the probability estimates. Id. at 999.

*Mohit*, 579 N.Y.S.2d at 991; see *supra* notes 88-95 and accompanying text (discussing *Frye* test).

"If . . . a reliable match is made, but the probabilities attached are not reliable, should the proponent of the evidence be denied its admissibility altogether?" Id.

"Id. at 993-94.

"Id. at 993.

"Id. at 992.
weight for the jury. In so holding, Mohit advocated an approach whereby the court could examine the probability estimates, modify them as necessary, and then submit them to the jury to be weighed for their usefulness and credibility. The court further suggested that the entire issue could be remedied if statutorily acceptable uniform laboratory standards and procedures were developed.

**CONCLUSION**

There are a great many concerns that the courts must address in determining the admissibility of DNA profiling evidence. While the Eighth Circuit feared that the leniency of the relevancy approach might cause unfair prejudice to the criminal defendant, the Second Circuit felt that the strictures of the *Two Bulls* approach would keep valuable probative evidence from the jury. It is suggested that the approach taken by the court in *People v. Mohit* would do much to alleviate these fears. The *Mohit* court provides an alternative whereby the traditional roles of judge and jury are left substantially intact. The approach it advocated ensures minimal unfair prejudice to the criminal defendant, while allowing maximum probative use of the currently available technology.

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164 Id. (citing *People v. Castro*, 144 Misc. 2d 956, 545 N.Y.S.2d 985 (1989)).
165 People v. Mohit, 579 N.Y.S.2d 990, 993 (Westchester County Ct. 1992). The court enumerated its own three-step analysis, posing the following questions:
1. Does the laboratory in question utilize procedures or protocols which are generally accepted as reliable within the scientific community (here the relevant scientific community being molecular biologists);
2. Are the principles utilized in the laboratory in calculating the probability of a match generally accepted as reliable within the scientific community (here the relevant scientific community being population geneticists and human geneticists);
3. If the laboratory procedures are acceptable, but the probability estimates are not, is the means of quantifying the probability of a match in a manner which would be generally accepted within the relevant scientific community, even if most would consider the estimate to be too high.

*Id.*
166 *Id.*