STATE V. ANDERSON, 1994-NMSC-089, 118 N.M. 284, 881 P.2d 29 (S. Ct. 1994)
CASE HISTORY ALERT: see ¶1 - affects 1993-NMCA-014

STATE OF NEW MEXICO, Petitioner-Appellee,
vs.
JAY ALLEN ANDERSON, Respondent-Appellant.

No. 21,069

SUPREME COURT OF NEW MEXICO

1994-NMSC-089, 118 N.M. 284, 881 P.2d 29

August 25, 1994, Filed. As Corrected October 19, 1994. As Corrected December 16, 1994

ORIGINAL PROCEEDING ON CERTIORARI. Ross Sanchez, District Judge

COUNSEL

Hon. Tom Udall, Attorney General, Margaret McLean, Assistant Attorney General, Santa Fe, New Mexico, for Petitioner-Appellee.

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JUDGES

BACA, FRANCHINI, FROST

AUTHOR: BACA

OPINION

*{*285}* **OPINION**

BACA, Justice.

{1} In this opinion, we address the subject of the admissibility of deoxyribonucleic acid ("DNA") evidence in New Mexico to inculpate the accused and, more specifically, the admissibility of this evidence obtained through the methods utilized by the Federal Bureau of Investigation ("FBI"). We granted the State's petition for writ of certiorari pursuant to SCRA 1986, 12-102(A)(6) (Repl. Pamp. 1992) to review the Court of

Appeals' decision holding the State's DNA evidence inadmissible at trial. The Court of Appeals held that the DNA evidence linking Defendant to the crime was inadmissible because the State failed to prove that the FBI's current database and statistical methodology were generally accepted in the scientific community as required by the rule set out in **Frye v. United States,** 54 App. D.C. 46, 293 F. 1013 (D.C. Cir. 1923). **State v. Anderson,** 115 N.M. 433, 853 P.2d 135 (Ct. App.), **cert. granted,** 115 N.M. 145, 848 P.2d 531 (1993). On appeal, the State argues that (1) the **Frye** standard is the appropriate standard to determine the admissibility of scientific evidence such as DNA typing and (2) that the procedures and calculations used in the scientific community to determine the probability of a coincidental match meets the **Frye** standard. Because this Court recently abandoned the use of the **Frye** test in New Mexico to determine the *{*286}* admissibility of scientific evidence, **State v. Alberico,** 116 N.M. 156, 861 P.2d 192 (1993), we address only one issue: Whether the procedures and calculations used in determining the probability of a coincidental DNA match meet the standard provided by our rules of evidence in SCRA 1986, 11-702 (Repl. Pamp. 1994) (testimony by experts), SCRA 1986, 11-703 (Repl. Pamp. 1994) (bases of expert opinion testimony), SCRA 1986, 11-403 (Repl. Pamp. 1994) (exclusion of relevant prejudicial evidence) and explained in detail by this Court in **Alberico.**[1] We reverse the Court of Appeals and affirm the trial court's ruling.

I. FACTS

{2} Defendant Jay Allen Anderson was indicted and charged with twenty-eight counts including kidnapping, criminal sexual penetration, attempted first-degree murder, and aggravated battery. The charges stemmed from the kidnapping and assault of Joni Hertz in 1988.

{3} In September of 1988, Hertz was driving from Oklahoma to California alone. Although she started out following a friend's vehicle, she became separated from her group. Hertz stopped at a convenience store in Albuquerque after discovering that her wallet had either been stolen or was lost. While she was talking with the clerk, Defendant entered the store and proceeded to join in the conversation. After Hertz told Defendant that she was alone and without any money, Defendant offered to give Hertz a $ 10 loan in exchange for a ride home. She accepted his offer and they drove to a field outside a trailer park.

{4} At the field, Defendant and Hertz engaged in conversation and then, abruptly, Defendant forced Hertz to perform oral sex. After ejaculating and forcing Hertz to swallow his semen, Defendant told Hertz that he was "going to have to kill [her]" because he did not want to get caught for his crime. Hertz pleaded with him not to kill her. Defendant severely beat her and left her unconscious. The plea and disposition agreement states that Defendant beat Hertz with "a block of wood and/or a steel barbell rendering her unconscious and causing injuries to her head requiring over 200 stitches."

{5} After Hertz identified Defendant as the perpetrator, he was arrested. The State recovered a sample of semen from Hertz's vomit and the FBI performed serological

tests to compare it with Defendant's DNA profile. DNA testing also showed that blood found on Defendant's jacket was consistent with Hertz's DNA profile. The State moved for a **Frye** hearing and was ordered to disclose everything relating to the DNA typing. Defendant filed a motion in limine requesting that unreliable scientific opinion evidence be ruled inadmissible. After the **Frye** hearing was held, the trial court ruled the DNA typing evidence admissible, stating:

> Testimony by the State's experts and the pertinent scientific literature convinces this Court by a preponderance of the evidence that the FBI's method for computing the statistical frequency of DNA pairings is a valid procedure and is generally accepted in the relevant scientific community.
>
> In summary, the protocol used by the FBI for DNA testing, including their method of computing the statistical frequency of DNA prints meets the standard for acceptance as required by **Frye.** The court also finds and concludes that the procedures are valid and reliable.
>
> . . .
>
> The Court finds and concludes that those scientists most qualified to assess the general validity of the FBI's protocol have spoken on this subject and are the determinative voice as contemplated by the Court in **Frye v. United States.** Motion to Exclude DNA Evidence is denied.

{6} Following this ruling, the State and Defendant entered into a plea and disposition agreement. The agreement set forth the facts surrounding the Defendant's criminal *{*287}* sexual acts. It also contained the results of serological evidence and the DNA typing. It stated:

> DNA typing analyses done by the Federal Bureau of Investigation show that the DNA profile obtained from sperm in the vomit matches the Defendant's DNA profile and the probability of selecting an unrelated individual from the population with that profile is approximately 1 in 6.2 million. DNA typing of the blood on Defendant's jacket produced a DNA profile matching that of Joni Hertz and the probability of selecting an unrelated individual at random with that same profile is approximately 1 in 30.5 million.

{7} Defendant appealed his conviction, arguing that the trial court committed reversible error by admitting the DNA typing evidence. The Court of Appeals reversed the trial court, holding that the FBI's method of computing population frequency statistics lacks general scientific acceptance because the binning procedure utilized by the FBI was controversial in the scientific community and therefore did not meet the standards of the **Frye** test. **Anderson,** 115 N.M. at 437, 444, 853 P.2d at 139, 146.

II. DNA BACKGROUND

{8} A basic understanding of the scientific principles and techniques underlying DNA typing[2] is essential in order to understand the legal issues relating to its admissibility. Unless otherwise stated, we derive our scientific explanation of DNA and DNA profiling from testimony given at the **Frye** hearing, from a report entitled "DNA Technology in Forensic Science," which the National Research Council published in April 1992, and from **Government of Virgin Islands v. Penn,** 838 F. Supp. 1054, 1057-73 (D.V.I. 1993) and **State v. Vandebogart,** 136 N.H. 365, 616 A.2d 483, 486 (N.H. 1992).

A. DNA Theory

{9} DNA forensic testing is used to determine the likelihood that a sample of blood, tissue, hair, or sperm came from a given person. DNA is a molecule found in all cells that have a nucleus, including white blood cells, sperm cells, cells surrounding hair roots, and the cells in saliva. DNA provides the genetic blueprint that determines the physical structures and individual characteristics of every living organism. The significant feature of DNA for forensic purposes is that, with the exception of identical twins, no two individuals have identical DNA. Furthermore, because DNA does not vary within a particular individual, a DNA molecule found in one cell will be identical to the DNA found in every other cell of that person's body.

{10} The DNA molecule is shaped like a double helix that resembles a twisted ladder. The "sides" of the ladder are composed of a chain of deoxyribose sugars and phosphates, while the "rungs" consist of a pair of nucleotide bases. The bases are made up of adenine (A), cytosine (C), guanine (G), and thymine (T). According to the "base pair rule," A can only bond with T and G can only bond with C. Thus, the order of the bases on one side of the rung will determine the order on the other side. That is, if one half of the "ladder" had a sequence of bases on its "side" that read "A-G-A-C-T-G," then the complementary strand from the other half of the "ladder" would read "T-C-T-G-A-C." The order in which these base pairs appear on the DNA ladder constitutes the genetic code for the cell. A sequence of base pairs responsible for producing a particular protein is called a " gene. " A gene, the basic unit of heredity, consists of a sequence of between 1000 and 2,000,000 nucleotides.

{11} Inheritable characteristics are controlled by pairs of genes, or alleles, that occupy the same sites, or loci, on paired chromosomes. Over 99% of these genes are identical among *{*288}* all human beings. These genes define us as humans, rather than animals, plants, or other forms of life. They account for the many shared characteristics of all human beings. The remaining genes--known as "polymorphic" genes because they vary in form from person to person--account for our unique characteristics as individuals. Many polymorphic genes are known to have definite functions. Some are responsible for the color of our hair or eyes, some for the shape of our body or the type of our blood. Other polymorphic genes, however, appear to have no function whatsoever. These "junk DNA" segments are called "variable number tandem repeats" ("VNTRs") and they typically consist of varying lengths of repeating sequences of base pairs. The site where a particular VNTR is located is called a "locus." The total fragment length of a polymorphism is called a restriction fragment length polymorphism ("RFLP")

and its length is determined by the number of VNTRs. Although all individuals have the same sequence of nucleotides at these VNTR locations, what differs from person to person is the number of times this sequence repeats itself. Thus, differences in DNA are detected by counting the number of times a particular sequence repeats at that VNTR. A variation of even one nucleotide in the sequence of DNA is detectable. Such a variation can be detected by applying a biological catalyst, called a "restriction enzyme" to the DNA. The restriction enzyme cuts the DNA into RFLPs depending on the cutting sites recognized by the enzymes. Because of its extensive variability, the VNTR class of RFLPs is the most useful in distinguishing among individuals.

B. DNA Profiling Techniques

{12} DNA analysis is generally performed by disassembling the ladder in several ways. The FBI, as well as two commercial laboratories, Cellmark and Lifecodes, use the RFLP method of analysis.

> RFLP analysis determines if there is a "match." A "match" does not mean that the suspect was definitely the source of the genetic material found at the crime scene, however, but simply that the suspect cannot be eliminated as the potential source. Even if there is a perfect match, there is a possibility that the two samples came from different people whose DNA patterns at the targeted loci are indistinguishable.

Vandebogart, 616 A.2d at 486. This Court, in an effort to be precise and scientifically accurate, will not paraphrase the operative steps of RFLP but will follow the example of most courts considering DNA methodology and incorporate the FBI written protocol. We reproduce the version used by the New Hampshire Supreme Court in **Vandebogart,** 616 A.2d at 487-88.

> 1. **Extraction of DNA.** The DNA is first extracted from the evidentiary sample by using chemical enzymes and then purified.
>
> 2. **Restriction of digestion.** The DNA is then cut with chemical scissors called "restriction endonucleases" [("restriction enzymes")]. These [enzymes] recognize certain base pairs and sever the DNA molecule at specifically targeted base pair sites to produce RFLPs.
>
> 3. **Gel electrophoresis.** The cut fragments of DNA molecules are next placed in an agarose gel which is later electrically [charged] to sort the fragments by length. Because DNA is negatively charged, the fragments will migrate toward the positive end of the gel. The distance traveled will depend upon the length of the fragment with the shorter fragments [because they are lighter] traveling further in the gel. [Fragments of known base pair lengths, called] molecular weight standards, [or] "size markers," are placed in separate lanes to measure the distance that the fragments travel. For comparison, several different samples

of DNA from known and unknown sources are run on the same gel, but in different tracks or lanes.

4. **Southern blotting or transfer.** Because the agarose gel is very difficult to work with, the fragments are transferred to a more functional surface by a method called "Southern transfer" [or "Southern blotting"]. A nylon membrane is placed over the gel, which is set upon a sponge saturated with sodium *{*289}* hydroxide solution. The solution carries the fragments from the gel onto the nylon membrane, and they become permanently fixed on the membrane, referred to as a "blot," in the same pattern as in the gel. Also during this step, a denaturation process severs each double-stranded DNA fragment into two single strands--one inherited from the father and one from the mother.

5. **Hybridization.** Next, a single-locus genetic probe is used to locate a specific polymorphic region of the DNA on the blot. A genetic probe is a single-stranded segment of DNA designed to complement a single-stranded DNA base sequence that is associated with a particular locus on a chromosomal pair. The probe will bond with any single-stranded fragments containing that particular base sequence. The typical result is that the probe will bind to DNA fragments at one or two locations in each lane, depending on whether the individual is homozygous or heterozygous for that particular allele. The genetic probe is tagged with a radioactive marker, which attaches to the probe and emits radiation without altering the function of the probe. The marker is used to determine the probe's position on the blot after it hybridizes with polymorphic segments.

6. **Autoradiography.** Autoradiography is the photographic process that reveals the position of the polymorphic DNA segments. After hybridization, the nylon membrane is placed between two pieces of X-ray film. The radioactive probes expose the film at their respective locations. Black bands appear on the processed film where the radioactive probes have bonded to the RFLPs, producing a DNA "print. " Typically, each probe will expose one or two bands for each DNA sample, which reflects the maternal or paternal contributions to the individual's DNA profile. The position of each band indicates the location of a polymorphic segment on the blot. Location, in turn, indicates the length of the DNA fragment that contains the [polymorphic DNA] segment. Because the length of the DNA fragments varies among individuals, the position of their bands on a DNA print can differentiate individuals.

After the first probe has been applied and the autoradiography process is complete, the first probe is stripped from the membrane. The hybridization process is then repeated on the same membrane using a second probe. This process is designed to locate a different VNTR base sequence on another chromosomal pair. The FBI usually repeats the hybridization and autoradiography processes using four or five different probes sequentially on a single blot. Repeating the processes with different probes decreases the likelihood that a match between the defendant's profile and the forensic profile is

a random event. It is rare for two unrelated persons to have eight or ten matching alleles across four or five different VNTR loci.

7. **Interpretation of autoradiographs.** The final step is to determine if a match exists in the two lanes of the autoradiograph between the DNA sample taken from the suspect and the forensic sample taken from the crime scene or victim. The FBI uses a two-stage procedure for deciding whether a match exists. First, the FBI looks for a visual match. A visual match means that the forensic sample of DNA and the suspect's DNA have the same number of bands in approximately the same locations on each autoradiograph. If no visual match exists, the FBI decides whether the non-match should be interpreted as inconclusive or as excluding the suspect. If a visual match is declared, the FBI uses a computer-assisted process to verify the existence of a match. Through a series of calculations, the computer will determine whether the difference in size of the fragments detected in the defendant's sample and the forensic samples is within accepted limits. If the size of the suspect's DNA fragments and the forensic samples is within plus or minus two and one-half percent of each other, *{*290}* then the visual match is confirmed. If the difference between the two exceeds the "matching criteria" of plus or minus two and one-half percent, then the autoradiograph is considered either inconclusive or as excluding the suspect. . . .

Once the suspect's DNA profile is declared to match the forensic sample,[3] the FBI relies on statistical methods used in population genetics to calculate the likelihood of a random match. "Fixed bin analysis" is the FBI's method for assigning to each band in a DNA profile a value or frequency that represents how often a particular allele may occur at a specific VNTR locus in a given population. To estimate population frequencies for particular alleles at targeted VNTR loci, the FBI has compiled data bases for Caucasian, Black, Asian, and Hispanic populations. [Although these population studies are broken down by racial groups, they are not further divided into ethnic subpopulations within these groups, such as (within the Caucasian group) Polish or Italian.] The FBI's Caucasian data base was derived from RFLP analyses of blood samples of approximately 225 FBI agent-trainees. The end result of the FBI's fixed bin analysis of RFLPs from a forensic sample is a statistic which estimates the probability that the DNA profile of an individual chosen at random from a given population might match the DNA profile for the forensic sample of the targeted VNTR loci.

To calculate this statistic, the FBI applies the "product rule." Use of the product rule in this context requires two assumptions about the statistical independence of allele matches: (1) that there is no greater or lesser likelihood that a person carrying one allele at a VNTR locus will also carry another particular allele at the same locus; and[] (2) that carrying one pair of alleles at a locus neither increases nor decreases the chance of carrying another particular pair at a different locus on a separate chromosome. If these assumptions are proper, then the product rule indicates that multiplying the population frequencies of all alleles detected in

> a DNA sample will yield an estimate of how common that DNA profile is in a given population.

Id. at 487-88; **see also Government of Virgin Islands v. Penn,** 838 F. Supp. at 1057-65 (giving a very detailed discussion of DNA, interpretation of autorads, and population genetics and statistics); **People v. Watson,** 257 Ill. App. 3d 915, 629 N.E.2d 634, 638-640, 196 Ill. Dec. 89 (Ill. App. Ct. 1994) (giving a variation of the same outline); **United States v. Jakobetz,** 955 F.2d 786, 792-93 (2nd Cir.), **cert. denied,** 121 L. Ed. 2d 63, 113 S. Ct. 104 (1992) (giving a simplified outline of the DNA technique); **Fishback v. People,** 851 P.2d 884 (Colo. 1993) (giving a slightly different interpretation and statistical analysis); **People v. Wesley,** 140 Misc. 2d 306, 533 N.Y.S.2d 643 (Co. Ct. 1988) (giving Lifecodes' operative steps for RFLP analysis).

III. STANDARD OF ADMISSIBILITY

{13} This Court recently held in **Alberico,** 116 N.M. at 167, 861 P.2d at 203, that "the **Frye** test 'should be rejected as an independent controlling standard of admissibility.'" **Id.** (quoting **United States v. Downing,** 753 F.2d 1224, 1237 (3d Cir. 1985)). This Court determined that the New Mexico Rules of Evidence should control the admissibility of novel, scientific evidence. Rule 702 of the New Mexico Rules of Evidence provides:

> If 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, *{*291}* training or education may testify thereto in the form of an opinion or otherwise.

SCRA 1986, 11-702.

This Court also held that

> the proper inquiry under Rule 702 is whether the subject of the expert's testimony is grounded in valid, objective science, that is "scientific, technical or other specialized knowledge," and whether the underlying scientific technique or method is reliable enough to prove what it purports to prove, that [it] is probative, so that it will assist the trier of fact.

Alberico, 116 N.M. at 168, 861 P.2d at 204.

{14} We laid out three prerequisites that had to be met under Rule 702 before expert opinion testimony could be admissible. "The first requirement is that the expert be qualified." **Id.** at 166, 861 P.2d at 202. "The second consideration for the admissibility of scientific evidence in the form of expert testimony is whether it will assist the trier of fact." **Id.** According to the Supreme Court of the United States, this condition is primarily one of relevance. **Daubert v. Merrell Dow Pharmaceuticals, Inc.,** 125 L. Ed. 2d 469, 113 S. Ct. 2786, 2795 (1993). In order to satisfy the precondition that the testimony

assist, or be "helpful" to the jury, the proponent of the testimony must demonstrate that the evidence bears "a valid scientific connection to the pertinent inquiry." 113 S. Ct. at 2796; **see also Jakobetz,** 955 F.2d at 796 (stating that the test under federal rule 702 subsumes a relevancy analysis and assumes a "threshold level of reliability"). Likewise, the third requirement set out by this Court, "which is closely related to assisting the trier of fact, is that an expert may testify only as to 'scientific, technical or other specialized knowledge'" with a reliable basis. **Alberico,** 116 N.M. at 166, 861 P.2d at 202. In short, "under the Rules the trial judge must ensure that any and all scientific testimony or evidence admitted is not only relevant, but reliable." **Daubert,** 113 S. Ct. at 2795.

{15} The **Daubert** Court rejected **Frye's** general acceptance test as the exclusive test for admissibility of novel scientific procedures or theories and redefined the standard for the admission of expert scientific testimony by holding that the **Frye** test was superseded by the adoption of the federal rules of evidence. **Id.** at 2793. The Court also provided a nonexclusive list of factors to be considered by the trial court when determining whether expert testimony as to novel scientific evidence is reliable (the third requirement in **Alberico). Id.** at 2796-97. It is this prong of the test that elicits the most controversy. In **Alberico** this Court favorably cited to **Daubert** for a list of the Supreme Court factors pertinent to the trial court's determination of whether the scientific evidence is reliable. **Alberico,** 116 N.M. at 167, 861 P.2d at 203. These factors include: (1) whether a theory or technique "can be (and has been) tested"; (2) "whether the theory or technique has been subjected to peer review and publication"; (3) "the known potential rate of error" in using a particular scientific technique "and the existence and maintenance of standards controlling the technique's operation"; and (4) whether the theory or technique has been generally accepted in the particular scientific field. **Daubert,** 113 S. Ct. at 2796-97. In **Alberico,** we set out another non-determinative factor--"whether the scientific technique is based upon well-recognized scientific principle and whether it is capable of supporting opinions based upon reasonable probability rather than conjecture." 116 N.M. at 167, 861 P.2d at 203.

{16} Thus, in a case where expert testimony is offered on a scientific topic unfamiliar to lay jurors, "the trial court's first task is to determine whether the testimony is sufficiently reliable and relevant to help the jury in reaching accurate results." **Kelly v. State,** 824 S.W.2d 568, 572 (Tex. Crim. App. 1992) (en banc); **see also Alberico,** 116 N.M. at 168, 861 P.2d at 204 (stating that the "inquiry must focus on the proof of reliability of the scientific technique or method upon which the expert testimony is premised"). If the trial court determines that the proffered expert testimony is reliable under Rule 702, the trial court must then determine if the scientific evidence should be excluded because its probative value is substantially outweighed *{*292}* by an unfair prejudicial effect under Rule 403.

{17} "The admission of expert testimony or other scientific evidence is peculiarly within the sound discretion of the trial court and will not be reversed absent a showing of abuse of that discretion." **Alberico,** 116 N.M. at 169, 861 P.2d at 205.

> An abuse of discretion standard of review, however, is not tantamount to rubber-stamping the trial judge's decision. It should not prevent an appellate court from conducting a meaningful analysis of the admission [of] scientific testimony to ensure that the trial judge's decision was in accordance with the Rules of Evidence and the evidence in the case.

Id. at 170, 861 P.2d at 206. Applying this standard of review and the trial court's standard under Rule 702 for admitting novel, scientific expert testimony, we proceed to determine whether the DNA evidence in this case was admissible.

IV. THE EXPERTS

{18} Stephen P. Daiger, Ph.D., was called as the State's first expert witness at the **Frye**[4] hearing. Following voir dire, the trial court admitted Dr. Daiger as an expert witness in forensic DNA testing, molecular biology, and population genetics based on his familiarity with the FBI's DNA typing procedures. Dr. Daiger is a molecular geneticist affiliated with the University of Texas Health Science Center and the Baylor College of Medicine. He has a Ph.D. in biology and has published numerous articles on the genetics of human disease.

{19} Dr. Daiger's testimony began with a description of the process of obtaining a DNA print on an autorad. He stated that an FBI examiner then makes a qualitative visual analysis. Next, the DNA bands are evaluated by a computer that uses a pre-determined measurement error of two and one-half percent. Dr. Daiger explained that this measurement is referred to as a "fixed bin." Dr. Daiger described the FBI's method of computing population statistics once a "match" has been declared. He stated that the FBI DNA typing and profiling procedures meet the standards of the scientific community and the appropriate standards for forensic testing. Because Defendant is Caucasian, the Caucasian database was used to determine the statistical probability that Defendant's DNA matched the DNA found in Hertz's vomit.

{20} When cross-examined regarding the FBI database, Dr. Daiger stated that the database is comprised of 400 FBI recruits from across the United States and that the database is separated into four ethnic groups--Caucasian, Black, Hispanic, and Asian. Dr. Daiger stated that the FBI population statistics are "intentionally very broad" and err to the accused's benefit to avoid false inclusion. In other words, any error is deliberately generous to the accused to avoid a false positive. Dr. Daiger further testified that his

> position is that the calculations done by the FBI, because they are so conservative in their choice of error ranges and in their choice of binning, will always provide an estimate which is either close to the correct estimate or in all cases larger than the correct estimate. That is, they have chosen a series of compromises and conditions that lead them to have an estimate which is always biased in favor of the defendant, and that in a forensic situation is precisely what I would have wanted to see, and I am very comfortable with what they have done.

{21} The State called Dr. Harold Deadman as its second witness. Dr. Deadman is a supervisory special agent for the FBI at its DNA analysis unit. Over defense objection, the trial court qualified Dr. Deadman as an expert witness in the field of DNA typing techniques used by the FBI. Dr. Deadman has a Ph.D. in organic chemistry and has worked in the FBI crime laboratory since 1972 and in its DNA analysis unit since 1987. Dr. Deadman described the six steps in the standard procedure of DNA typing (extraction, fragmentation, gel electrophoresis, Southern blotting, hybridization, and autoradiography). *{*293}* Dr. Deadman, like Dr. Daiger, testified that "the binning process itself is conservative" and described in detail how the binning calculation actually works.

{22} Generally, the DNA profiles for the different racial groups contain two bands or DNA markers. The specific population database can be used to generate an expected frequency for each DNA marker. Once a frequency for a marker is determined, that information can be used to generate a profile frequency. Because it is not possible to measure exactly the size of a particular DNA fragment, the DNA markers from the specific population are used to determine fragment frequencies. Bands are placed in particular bins which are larger than the repeat sequence (RFLP) so that multiple bands are in a bin. Even though a band's real frequency may be low, every band in the bin is added together, creating a higher frequency and requiring a more exact, and more conservative, match. **See Springfield v. State,** 860 P.2d 435, 445 (Wyo. 1993) for a more detailed description of the FBI binning procedure.

{23} In regard to the "match" between Defendant's DNA profile and the DNA profile produced by the semen found in Hertz's vomit, Dr. Deadman also testified that the FBI procedure is generally accepted by the scientific community. He testified that "the probability of selecting someone at random from a Caucasian population and finding and obtaining an individual that's unrelated to the defendant that has a profile like the profile developed in this case [was] . . . approximately one in 6.2 million."

{24} The defense called four expert witnesses. The first expert witness called for the defense was Dr. Randall T. Libby. Over the State's objection, Dr. Libby was qualified as an expert witness in molecular biology and DNA typing. Dr. Libby, a molecular biologist, is a research associate in the Department of Genetics at the University of Washington. He has had ten years of experience using the various procedures involved in RFLP analysis, including DNA extraction, restriction digestion, electrophoresis, Southern blotting, and autoradiography. He has published numerous articles in the field of molecular genetics and reviews articles for the **Journal of Biochemistry**, a major academic journal in the field, and for the National Institute of Health and the American Cancer Society. He has studied the protocols used by the FBI as well as by Lifecodes and Cellmark and has visited all three of those DNA testing laboratories as well as the FBI research laboratory in Quantico, Virginia.

{25} Dr. Libby testified that the FBI has no procedure for verifying the quality of the probes it uses. Additionally, he claimed that a testing laboratory should not be given police reports or anything else with the DNA samples in order to avoid evaluator bias.

Dr. Libby testified that the only way to test the reliability of the FBI's procedures is by conducting external proficiency testing. He further stated that the FBI currently conducts only internal testing.

{26} The second witness called was Dr. Laurence Mueller. Dr. Mueller was qualified as an expert in evolutionary biology and population genetics. He is an associate professor at the University of California, Irvine. He has a Ph.D. in ecology and did four years of post-doctoral work at Stanford University in the field of theoretical population genetics. He has published over 25 peer-reviewed articles in the fields of population genetics and evolutionary biology and has written two articles specifically on the population genetics of the VNTR alleles used in DNA typing.

{27} Dr. Mueller testified that the FBI's reliance on the product rule, which produces a resulting statistical probability through the method of multiplying together the frequencies with which each band representative of a DNA fragment appears in a broad database, is very problematic. He testified that the problem with this method is that it is based on the incorrect assumptions that (1) members of the racial groups represented by the broad databases--Caucasians, Blacks, and Hispanics--mate within their groups at random i.e., without regard to religion, ethnicity, and geography; (2) the DNA fragments identified by DNA processing behave independently; (3) there is no natural selection among humans; (4) there are no random *{*294}* genetic drifts;[5] and (5) there are no mutations.

{28} Dr. Mueller further testified that ethnic subgroups tend to mate endogamously (i.e., within a specific subgroup) with persons of like religion or ethnicity or who live within close geographical distance. According to Dr. Mueller such endogamous mating tends to maintain genetic differences between subgroups that existed when ancestral populations emigrated to the United States and has not yet had sufficient time to dissipate. As a result, the subgroups may have substantial differences in the frequency of a given DNA fragment or VNTR allele identified in the processing step of DNA analysis. A given VNTR allele may be relatively common in some subgroups but not in the broader database. In his opinion, as a result of the FBI's failure to account for the possibility of substructures or subgroups within the Caucasian population, in a worst-case scenario the FBI's computed frequency of DNA prints could be off by a factor of millions.

{29} Dr. Mueller disagreed with Dr. Daiger's opinion that the FBI binning method produces a statistically conservative number. He stated that the FBI's statistics could not be considered valid until the issue of substructures in the population had been addressed. Dr. Mueller testified that the procedures the FBI used to compute statistics were not acceptable to population geneticists because the underlying assumptions had not been validated.

{30} Professor Seymour Geisser was the third defense expert witness called. He was qualified as an expert in the fields of statistics, biostatistics and probability theory. Dr. Geisser is the director of the School of Statistics at the University of Minnesota. He has

published over 130 peer-reviewed articles, chapters, and books and has received numerous distinguished awards from professional societies in recognition of his eminence in the field of biostatistics and biometry. He has also studied the procedures used to compute frequency statistics by the FBI as well as by Cellmark and Lifecodes. Dr. Geisser's testimony corroborated Dr. Mueller's testimony in that Dr. Geisser questioned the FBI's database because, in his opinion, it did not represent a random sampling of the population. He also believed that the FBI had not made an adequate demonstration that the alleles are independent. Dr. Geisser testified that if the alleles are in fact not independent, the product rule would produce an erroneous result because the product rule depends completely on statistical independence. He further stated that, in light of his concerns with the FBI's methods of computing statistical probabilities, he did not believe that the FBI's procedure was accepted in the scientific community.

{31} Dr. Charles Taylor was called as the fourth and final defense expert witness. Following voir dire, Dr. Taylor was qualified as an expert in the fields of statistics and population genetics. He is a professor of biology at the University of California, Los Angeles, has a Ph.D. in ecology and evolution, and is a specialist in population genetics and the application of statistics and probability theory to problems in biology and genetics. He has published approximately 50 articles in peer-reviewed scientific journals. Dr. Taylor testified that, in his opinion, the FBI procedure for computing the statistical probability that a random person had the same DNA profile as that developed in the case was invalid and not generally accepted in the scientific community. Dr. Taylor testified that "the most serious problem with the population genetics *{*295}* of [the FBI's] analysis is that it assumes there is no population structure. That is to say, it assumes that the Caucasian population is randomly mating and has uniformed [sic] gene frequencies." Dr. Taylor also stated that the FBI uses "different rules for assigning matches and for calculating the probability of those matches." Further, Dr. Taylor testified that the sample from which the FBI extrapolates "the gene frequencies for Caucasians generally, is drawn from a highly non-random sample and it's probably not characteristic of a Caucasian population in the U.S. as a whole." Dr. Taylor presented data from an Oxford University study of human mating patterns in San Francisco that showed humans are far more likely to marry others of their same social, ethnic, and religious group than to marry across these lines. He also refuted Dr. Daiger's testimony that any underestimation of genotype frequency caused by population structure or the lack of statistical independence would be more than made up by the tendency of the FBI procedure to overestimate allele frequency. Dr. Taylor stated that there is no way of knowing how "generous" the FBI's bins would need to be in order to compensate for the concerns raised by the defense experts.

{32} The final State's witness, called in rebuttal, was Dr. Bruce Budowle, the FBI director of research in DNA technology responsible for developing the FBI DNA test. He was qualified as an expert in human genetics, forensic application of DNA typing, and statistics. Dr. Budowle has a Ph.D. in genetics and is a research chemist at the FBI. He testified that there is simply no authority for either the proposition that there is

substructure in the Caucasian population or that there is any effect of a substructure, if it exists, on the calculation of a coincidental match.

V. LEGAL DISCUSSION

A. Other Jurisdictions

{33} Before applying New Mexico law to the use of DNA evidence to inculpate the accused in criminal cases, we believe it would be helpful to set out how other jurisdictions around the country deal with this issue. In our research we have found that different jurisdictions have developed various ways of dealing with DNA typing evidence. A majority of jurisdictions have held that DNA profiling meets the relevancy standards similar to New Mexico's Rule 702. **See. e.g., United States v. Bonds,** 12 F.3d 540, 566-67 (6th Cir. 1993), **aff'g United States v. Yee,** 134 F.R.D. 161 (N.D. Ohio 1991); **United States v. Martinez,** 3 F.3d 1191, 1198-99 (8th Cir. 1993), **cert. denied,** 126 L. Ed. 2d 697, 114 S. Ct. 734 (1994); **United States v. Jakobetz,** 955 F.2d 786, 800 (2d Cir.), **cert. denied,** 121 L. Ed. 2d 63, 113 S. Ct. 104 (1992); **Government of Virgin Islands v. Penn,** 838 F. Supp. 1054, 1073-74 (D.V.I. 1993); **Andrews v. State,** 533 So. 2d 841, 849-50 (Fla. Dist. Ct. App. 1988), **review denied,** 542 So. 2d 1332 (Fla. 1989); **State v. Montalbo,** 73 Haw. 130, 828 P.2d 1274, 1282 (Haw. 1992); **State v. Brown,** 470 N.W.2d 30, 32-33 (Iowa 1991); **State v. Futrell,** 112 N.C. App. 651, 436 S.E.2d 884, 890-91 (Ct. App. 1993); **State v. Pierce,** 64 Ohio St. 3d 490, 597 N.E.2d 107, 115 (Ohio 1992); **State v. Futch,** 123 Ore. App. 176, 860 P.2d 264, 272-73 (Ct. App. 1993) (en banc); **Kelly v. State,** 824 S.W.2d 568, 574 (Tex. Crim. App. 1992) (en banc); **Spencer v. Commonwealth,** 238 Va. 275, 384 S.E.2d 775, 783 (Va. 1989), **cert. denied,** 493 U.S. 1036, 107 L. Ed. 2d 775, 110 S. Ct. 759 (1990); **Spencer v. Commonwealth,** 238 Va. 295, 384 S.E.2d 785, 797 (Va. 1989), **cert. denied,** 493 U.S. 1093 (1990); **State v. Woodall,** 182 W. Va. 15, 385 S.E.2d 253, 260 (W. Va. 1989); **Springfield v. State,** 860 P.2d 435 (Wyo. 1993).

{34} Even though the clear majority of jurisdictions following the Rules of Evidence in determining admissibility of scientific evidence would admit the DNA evidence, Delaware, a 702 state, allows admission of DNA evidence only "when both the evidence of a match and the statistical significance of the match are admissible." **Nelson v. State,** 628 A.2d 69, 76 (Del. 1993). The court held that "the statistical calculation is essential for the evidence to have relevance or meaning to the trier of fact." **Id.** The Georgia Supreme Court concluded that Lifecode's use of the product rule to determine a coincidental match was not proven reliable because no expert had studied Lifecode's database. The Court, however, allowed the DNA evidence so long as the *{*296}* most conservative number agreed upon by the experts (based only on the database and not a population theory) was the statistic given. **Caldwell v. State,** 260 Ga. 278, 393 S.E.2d 436, 443 (Ga. 1990).

{35} Frye jurisdictions have also found DNA evidence to be admissible (determining the testing methods to be generally accepted in the relevant scientific communities of molecular biology and population genetics). **See. e.g., Fishback v. People,** 851 P.2d

884, 893-95 (Colo. 1993) (en banc); **Smith v. Deppish,** 248 Kan. 217, 807 P.2d 144, 159 (Kan. 1991); **Polk v. State,** 612 So. 2d 381, 391 (Miss. 1992); **People v. Wesley,** 83 N.Y.2d 417, 633 N.E.2d 451, 455-56, 611 N.Y.S.2d 97 (N.Y. 1994); **State v. Ford,** 301 S.C. 485, 392 S.E.2d 781, 784 (S.C. 1990); **State v. Kalakosky,** 121 Wash. 2d 525, 852 P.2d 1064, 1074 (Wash. 1993) (en banc); **cf. State v. Cauthron,** 120 Wash. 2d 879, 846 P.2d 502, 515-17 (Wash. 1993) (en banc) (testimony regarding a DNA match held inadmissible because no probability statistics given). Some **Frye** jurisdictions admit the DNA typing evidence while prohibiting or limiting the admission of evidence regarding the statistical significance of a declared match, **see. e.g., United States v. Porter,** 618 A.2d 629, 641-44 (D.C. 1992) (limiting statistical calculation to the most conservative number); **People v. Mohit,** 153 Misc. 2d 22, 579 N.Y.S.2d 990 (County Ct. 1992) (admitting DNA typing evidence but limiting statistical calculations to the most conservative estimate), and, like Delaware, some **Frye** jurisdictions have completely rejected the DNA evidence on their conclusion that the statistical methodology has not been generally accepted in the field of population genetics. **See. e.g., People v. Barney,** 8 Cal. App. 4th 798, 10 Cal. Rptr.2d 731, 745 (Ct. App. 1992) (prohibiting DNA typing evidence as well as statistical calculations because population geneticists disagreed about the validity of the particular statistical calculation procedures); **Commonwealth v. Curnin,** 409 Mass. 218, 565 N.E.2d 440, 442-45 (Mass. 1991) (holding in case in which no expert testified regarding general acceptance and no study of database had been made that the particular statistical methodology employed was not generally accepted in the relevant scientific field, making the DNA typing evidence meaningless); **State v. Schwartz,** 447 N.W.2d 422, 427-29 (Minn. 1989) (holding in case in which Cellmark laboratory refused to produce information regarding methodology and its database that DNA typing evidence and statistical probabilities were inadmissible and limiting use of population frequency statistics because "juries in criminal cases may give undue weight and deference to presented statistical evidence"); **Vandebogart,** 616 A.2d at 494 (holding because of the debate among population geneticists over population substructure that "the statistical techniques that the FBI used to estimate population frequencies is not generally accepted among population and human population geneticists," and that a "match is virtually meaningless without a statistical probability expressing the frequency with which a match could occur").

{36} Finally, at least one state court (West Virginia, a jurisdiction that uses the rules of evidence to test admissibility) has held that lower courts may take judicial notice of DNA typing reliability. **Woodall,** 182 W. Va. 15, 385 S.E.2d at 260.

B. Alberico and **Daubert** Applied

{37} The State originally argued in their brief-in-chief that the **Frye** standard was the appropriate standard for admissibility of novel scientific evidence and that "DNA typing evidence, including the laboratory procedure and the calculation of the probability of a coincidental match, meets the **Frye** standard." In their reply brief, however, the State has changed their argument pursuant to our recent holding in **Alberico** and argues that DNA typing evidence, including the laboratory procedure and the calculation of the

probability of coincidental match, meets the standard under Rules 702 and 703 as set out in **Alberico** and **Daubert.** Accordingly, we apply the **Alberico/Daubert** factors to the evidence in this case.

{38} Applying the three prerequisites laid out in **Alberico,** it is clear that all of the experts were qualified. They are all prominent in the field of either molecular biology, population genetics, statistics, or forensic DNA typing. Additionally, there is little question that a DNA profile is relevant to this case. A *{*297}* major issue here is whether Defendant was present at the scene of the crime. Evidence that links Defendant's DNA to DNA gathered from Hertz's clothing and vomit is helpful to the jury in that it would tend to make the existence of the fact that Defendant was present at the crime scene more probable than it would be without the evidence. **See Alberico,** 116 N.M. at 166, 861 P.2d at 202; **Futch,** 860 P.2d at 270; SCRA 1986, 11-403 (Repl. Pamp. 1994). The arguments in this case concern the third prerequisite--whether the subject of the State's expert testimony is grounded in valid, objective science, that is "scientific, technical or other specialized knowledge," and whether the underlying scientific technique or method is reliable enough to prove what it purports to prove. In order to determine if the trial court correctly determined that the DNA typing evidence was reliable and, thus, admissible, we must engage in a review of the **Alberico/Daubert** factors.

1. Whether the Proffered Technique Can Be (and Has Been) Tested

{39} We agree with the Sixth Circuit's analysis of this question in **Bonds,** 12 F.3d at 559, in which the court stated:

> It seems clear that this first **Daubert** factor is not really in dispute. The **Daubert** Court found that "'the criterion of the scientific status of a theory is its . . . refutability.'" Defendants vociferously dispute the accuracy of the match results and the adequacy of the testing done, and in refutation have presented evidence about deficiencies in both the results and the testing of the results. Thus, it appears that by attempting to refute the FBI's theory and methods with evidence about deficiencies in both the results and the testing of the results, the defendants have conceded that the theory and methods can be tested.

Id. at 559 (citation omitted).

2. Whether the Theory or Technique Has Been Subjected to Peer Review and Publication

> **{40}** At the outset, it is important to note that the **Daubert** Court specifically stated that
>
> > publication (which is but one element of peer review) is not a **sine qua non** of admissibility; it does not necessarily correlate with reliability, and in some instances well-grounded but innovative theories will not have been published. . . . The fact of publication (or lack thereof) in a peer-reviewed

> journal thus will be a relevant, though not dispositive, consideration in assessing the scientific validity of a particular technique or methodology on which an opinion is premised.

113 S. Ct. at 2797 (citations omitted).

{41} Here, the FBI's procedures have received peer review. Evidence of this fact is the plethora of articles admitted as exhibits in this case. Although many of the articles written by FBI technicians have not been published in a "peer-reviewed journal" in the strict sense of that term,[6] the trial court found that the FBI's techniques received adequate scrutiny through "presentations at scientific conferences, workshops and other forums for the exchange of ideas" and through the dissemination of unpublished and non-peer-reviewed writings. Additionally, the FBI has published numerous articles. Among them are F. Samuel Baechtel, **A Primer on the Methods Used in the Typing of DNA,** 15 Crime Lab. Dig. 3 (Supp. No. 1 1988); Bruce Budowle et al., **An Introduction to the Methods of DNA Analysis Under Investigation in the FBI Laboratory,** 15 Crime Lab. Dig. 8 (1988); F. Samuel Baechtel, **Recovery of DNA from Human Biological Specimens,** 15 Crime Lab. Dig. 95 (1988); Bruce Budowle, **The RFLP Technique,** 15 Crime Lab. Dig. 97 (1988); Catherine Theisen Comey, **The Use of DNA Amplification in the Analysis of Forensic Evidence,** 15 Crime Lab. Dig. 99 (1988); Dwight E. Adams, **Validation of the FBI Procedure for DNA Analysis: A Summary,** 15 Crime Lab. Dig. 106 (1988); William G. Eubanks, **FBI Laboratory DNA Evidence Examination Policy,** 15 Crime Lab. Dig. 114 (1988).

*{*298}* **{42}** Defendant contends that the trial court erred in finding that the FBI's methods had undergone adequate scrutiny, stating that Dr. Libby and Dr. Taylor had testified that they highly questioned the FBI's published and unpublished materials. Moreover, Defendant asserts that in subsequent cases, the FBI's "Fixed Bin" paper was heavily criticized by a "number of other experts as scientifically inadequate and unfounded." Although we agree that scientists in population genetics have engaged in a heated debate over the accuracy of the FBI's methods, we believe this is a question of weight and not of admissibility. The fact is that the FBI's techniques have been subjected to peer review and publication and, therefore, this factor is satisfied.

3. Consideration of the Known or Potential Rate of Error of the Scientific Technique

{43} This **Alberico/Daubert** factor requires the court to examine the standards controlling the DNA profiling process and the known or potential rate of error that might result from the process. **Daubert,** 113 S. Ct. at 2792. We agree with the District Court of the Virgin Islands that this examination involves two parts. "In the first part, the court examines the means by which the FBI prevents both potential sources of human error in the execution of the process and potential error caused by imperfections inherent in the process." **Penn,** 838 F. Supp. at 1066. The second part of this factor involves the statistics used in DNA profiling. "Since statistics concern estimates, the DNA profiling

process involves degrees of uncertainty. The second part of this analysis examines to what extent the FBI attempts to resolve the uncertainties in the defendant's favor." **Id.**

a. Laboratory procedures and processes

{44} The State contends that because "three proficiency tests were conducted without any report of an error," and "the FBI protocol was available to the defense for 13 months to evaluate and samples were available for independent DNA testing," this factor was easily met. Defendant, on the other hand, argues that "the FBI's proficiency testing was inadequate." Defendant directs this Court's attention to a report entitled **DNA Technology in Forensic Science** (1992) ("the NRC report") and compiled by the Committee on DNA Technology in Forensic Science, the Board on Biology, the Commission on Life Sciences, and the National Research Council. The NRC report states that proficiency testing is the most important type of validation research and that "there is no substitute for rigorous external proficiency testing via blind trials." NRC report at 55. According to Defendant "the FBI's proficiency testing was not blind, it was not external, and it most assuredly was not rigorous. Only nine simulated cases had been processed" and "the analysts knew they were being tested." Moreover, the Defendant asserts that "the FBI had not adequately validated its matching standard. Dr. Geisser testified that the FBI did not have adequate data regarding the measurement error of its test and that what data were available suggested that the FBI's matching criteria is too broad."

{45} Defendant argues that the FBI's statistical estimates are invalid because (1) they depend "on the untested assumption that there is random mating in human populations"; (2) the FBI fails to take into account substructuring of the population; (3) the binning method is not conservative; (4) the FBI's database is inappropriate; and (5) the FBI underestimates the frequency of alleles. Defendant also contends that the DNA evidence should not have been admitted because the FBI's testing methods fail to meet the standards set out by various scientific and professional groups. Defendant's argument is based on the fact that the blood samples of the FBI agents who made up the database used in this case were not divided into ethnic subgroups within the caucasian group. Defendant directs this Court to the scientific literature, including the NRC report and case law (cited in subsection A) criticizing the FBI's matching procedures as well as the product rule.

{46} The NRC report states that rigorous empirical studies are essential for establishing the match standard. "The match criterion must be based on the actual variability in measurement observed in appropriate test *{*299}* experiments conducted in each testing laboratory." NRC report at 54. Furthermore, "the match criterion must be based on reproducibility studies that show the actual degree of variability observed when multiple samples from the same person are separately prepared and analyzed under typical forensic conditions." NRC report at 61-62.

{47} The State has not directed this Court to any testimony or evidence to refute Defendant's claims, and we have been unable to locate any evidence in the record

showing that the FBI's procedures include sufficient proficiency testing. We agree with the Sixth Circuit that "the deficiencies in calculating the rate of error and the failure to conduct external blind proficiency tests are troubling." **Bonds,** 12 F.3d at 560. This factor, however, is only part of one factor that is included in a list of non-exclusive factors set out by the **Daubert** Court and, in this instance, speaks to the weight of the evidence and not to its admissibility. **See People v. Moore,** 194 A.D.2d 32, 604 N.Y.S.2d 976, 977 (App. Div. 1993), **appeal denied,** 634 N.E.2d 988 (1994); **cf. Fishback,** 851 P.2d at 893 (holding that questions involving the implementation of particular technology go to the weight and not the admissibility of DNA typing evidence under **Frye).**

b. Resolving statistical uncertainties in the Defendant's favor

{48} Although the Defendant argues that the FBI's methods have a huge potential for error, the State contends that "like other methods of identification, a random match probability is an evidentiary tool to determine the ultimate guilt or innocence of the accused." Moreover, the State argues that "the FBI procedure adequately accounts for any potential substructure and provides an underestimate, i.e., conservative estimate, of the true frequency of a DNA profile." Defendant disagrees with the State's assessment and argues that "the FBI has failed to test the key assumption underlying its statistical estimates--the assumption that VNTR alleles are statistically independent." Defendant directs this Court to a statement made by the State's rebuttal expert witness, Dr. Budowle, that '"**there is no evidence to support the assertion** that a sample population adequately represents the true population or other subpopulation groups.'" **Anderson,** 115 N.M. at 443, 853 P.2d at 145 (quoting Bruce Budowle & Keith L. Monson, **A Statistical Approach for VNTR Analysis** 3 (unpublished manuscript) (emphasis added by Court of Appeals)).

{49} Defendant's expert testified that there is a method to test whether humans mate randomly. Dr. Mueller testified that the only way to test the theory is to sample a variety of ethnically distinctive subgroups and determine whether they vary significantly in the frequency of alleles. The NRC has recommended that population differentiation be "assessed through direct studies of allele frequencies in ethnic groups." NRC report at 82. Pending completion of such studies, the NRC further recommended that statistical procedures like those used by the FBI to compute the statistics be abandoned in favor of a far more conservative method called "the interim ceiling principle."

{50} "This substructure argument involves a dispute over the accuracy of the probability results, and thus this criticism goes to the weight of the evidence, not its admissibility." **Bonds,** 12 F.3d at 564; **Deppish,** 807 P.2d at 159; **Wesley,** 633 N.E.2d at 457; **Pierce,** 597 N.E.2d at 112, 115; **cf. Kalakosky,** 852 P.2d at 1073 (stating that "alleged infirmities in the performance of a test usually go to the weight of the evidence, not to its admissibility"); **Springfield,** 860 P.2d at 447. The experts clearly outlined the controversy and counsel had the opportunity to engage in vigorous cross-examination. The trier of fact has the right to believe or disbelieve the testimony it hears.

4. The Degree to Which DNA Profiling is Accepted by the Relevant Scientific Community

{51} Although general acceptance is not a requirement for admissibility under Rules 702 and 703, it is a factor the court may consider. "Widespread acceptance can be an important factor in ruling particular evidence admissible, and a 'known technique that has been able to attract only minimal support within *{*300}* the community' may properly be viewed with skepticism. **Daubert,** 113 S. Ct. at 2797 (quoting **Downing,** 753 F.2d at 1238). The concept of examining the "general acceptance" of a particular scientific theory and procedure stems from **Frye,** in which the D.C. Circuit held:

> While courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs.

293 F. at 1014.

{52} The **Frye** test was first adopted in New Mexico in 1952 when this Court affirmed a district court's exclusion of expert opinion testimony regarding truth serum that was not "reliable or generally approved and accepted by members of the medical profession specializing in psychiatry." **State v. Lindemuth,** 56 N.M. 257, 271, 243 P.2d 325, 334 (1952). The **Lindemuth** Court held that in order for scientific evidence to be admissible, the scientific technique or principle about which the expert proposes to testify must be "accorded general scientific recognition." **Id.** at 274, 243 P.2d at 336. The test consistently used in New Mexico to determine "general acceptance" has been to show "that the reliability of the underlying scientific principles has been accepted by the scientific community." **Montoya v. Metropolitan Court,** 98 N.M. 616, 617, 651 P.2d 1260, 1261 (1982); **see also Alberico,** 116 N.M. at 165, 861 P.2d at 201 (noting the ambiguity of the term "general acceptance and stating that the standard provides a safeguard against specious techniques); **State v. Gallegos,** 104 N.M. 247, 253, 719 P.2d 1268, 1274 (Ct. App. 1986) (abrogated by **Alberico,** but citing favorably to **People v. Torres,** 128 Misc. 2d 129, 488 N.Y.S.2d 358 (1985) in which the court determined the battered wife syndrome to have gained "('substantial enough scientific acceptance to warrant admissibility.'" 488 N.Y.S.2d at 363).

{53} Many jurisdictions still using the **Frye** test have held that the general scientific theory underlying DNA printing analysis is almost universally accepted in the scientific community. **See. e.g., Caldwell,** 393 S.E.2d at 441; **Schwartz,** 447 N.W.2d at 425-26; **Polk,** 612 So. 2d at 391; **People v. Castro,** 144 Misc. 2d 956, 545 N.Y.S.2d 985, 995 (Sup. Ct. 1989); **Spencer,** 384 S.E.2d at 783; **Spencer,** 384 S.E.2d at 797.

{54} In the case at bar the trial court concluded that "testimony by the State's experts and the pertinent scientific literature convinces this court by a preponderance of the evidence that the FBI's method for computing the statistical frequency of DNA prints is a valid procedure and is generally accepted in the relevant scientific community."

{55} The trial court's findings indicate that the degree of acceptance in the scientific community of the theory of DNA profiling and of the basic procedures used by the FBI laboratory in this case is sufficient to meet the general acceptance requirement and the scientific validity requirement. The State's experts, one of whom was from outside the FBI laboratory, testified that the FBI's DNA procedures were generally accepted in the scientific community.

{56} Defendant contends that although the procedures utilized for the DNA typing itself may be generally accepted in the scientific community, the matching and statistical method used by the FBI (the product rule) to determine the probability of a random match has not been generally accepted and, thus, those statistics do not assist The trier of fact. Therefore, Defendant argues, the DNA typing evidence is worthless and neither it nor the statistical calculations should be admissible.

{57} Although the defense experts all testified that the FBI's procedures are not generally accepted in the scientific community, they only established that there is a substantial amount of controversy over whether the statistical probabilities resulting from the FBI's methods are reliable and accurate. "The potential of ethnic substructure does not mean that the theory and procedures used by the FBI are not generally accepted; it means only that there is a dispute over whether the results are as accurate as they might be and what, if any, weight the jury should give those results." **Bonds,** 12 F.3d at 564-65; *{*301}* **see also Montalbo,** 828 P.2d at 1282; **Futrell,** 436 S.E.2d at 890-91; **Pierce,** 597 N.E.2d at 115; **Futch,** 860 P.2d at 273; **Kalakosky,** 852 P.2d at 1072; **Springfield,** 860 P.2d at 447. Defendant's experts indicated that the FBI's methods were flawed because they did not take into account ethnic substructure. The State's experts, however, testified that the results were not distorted by the possibility of ethnic substructure because the FBI's methods are conservative. In fact, we feel it is important to note that Defendant's experts could only speculate as to the effect of ethnic substructure because there is no positive evidence that one exists. Moreover, there was testimony that the FBI's conservative procedures were sufficient to compensate for the possibility of error in data collection and sample size, and that these procedures resulted in statistics that were actually incorrect, in that they overestimated the probability of chance matches within any population.

{58} We hold that questions about the accuracy of results goes to the weight of the evidence and is properly left to the jury. As the Court in **Jakobetz,** 955 F.2d at 800, stated:

> The district court should focus on whether accepted protocol was adequately followed in a specific case, but the court, in exercising its discretion, should be mindful that this issue should go more to the weight than to the admissibility of the evidence. Rarely should such a factual determination be excluded from jury consideration. With adequate cautionary instructions from the trial judge, vigorous cross-examination of the government's experts, and challenging testimony from defense experts, the jury should be allowed to make its own factual determination as to whether the evidence is reliable.

{59} Accordingly, we hold that the trial court may only examine whether the principles and methodology used are scientifically valid and generally accepted. The assessment of the validity and reliability of the conclusions drawn by the experts, however, is a jury question. The jury is free to believe or disbelieve the expert testimony. **See State ex rel. Human Servs. Dep't v. Coleman,** 104 N.M. 500, 504, 723 P.2d 971 (Ct. App. 1986). In summary, we hold that under the standard set forth in **Alberico** for the admission of scientific evidence and expert testimony, the trial court did not abuse its discretion by finding the DNA evidence admissible.

C. Rule 703

{60} We next address Defendant's argument that the DNA typing evidence does not meet the standard for admissibility under Rule 703. Rule 703 provides:

> The facts or data in the particular case upon which an expert bases an opinion or inference may be those perceived by or made known to the expert at or before the hearing. If of a type reasonably relied upon by experts in the particular field in forming opinions or inferences upon the subject, the facts or data need not be admissible in evidence.

Defendant contends that the FBI's method for calculating the probability of a coincidental match does not use the type of data reasonably relied upon by experts in the field and is, therefore, inadmissible.

{61} We conclude that the State's experts based their opinions on data and facts reasonably relied upon by experts in molecular biology and population genetics. Our determination that the FBI's theory and procedures are "scientifically valid" and "generally accepted" in the pertinent scientific community under Rule 702 indicates that the experts testified about scientific knowledge based on sound methodology. **See Ambrosini v. Labarraque,** 296 U.S. App. D.C. 183, 966 F.2d 1464 (D.C. Cir. 1992) (court must know basis for expert's opinion before it can determine that basis is not of a type reasonably relied on by experts in the field). Accordingly, we find Defendant's argument to be without merit.

D. Rule 403

{62} Having concluded that the trial court did not abuse its discretion in admitting the DNA typing evidence under Rules 702 and 703, we next address Defendant's argument that the DNA evidence was improperly admitted by the trial court under Rule 403 because its probative value is outweighed by *{*302}* the prejudicial impact of the evidence. Rule 403 provides:

> 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, or by considerations of undue delay, waste of time or needless presentation of cumulative evidence.

Defendant contends that DNA evidence carries with it an "aura of infallibility" that will tend to mislead or confuse the jury, and therefore its probative value is outweighed by its prejudicial impact. We cannot agree.

{63} "The trial court is vested with great discretion in applying Rule 403, and it will not be reversed absent an abuse of that discretion." **State v. Chamberlain,** 112 N.M. 723, 726, 819 P.2d 673, 676 (1991). Unfair prejudice does not mean the damage to a defendant's case that results from the legitimate probative force of the evidence; rather it refers to evidence that tends to suggest decision on an improper basis. **State v. Duncan,** 113 N.M. 637, 643, 830 P.2d 554, 560 (Ct. App. 1990), **aff'd,** 111 N.M. 354, 805 P.2d 621 (1991). Here, the evidence and the testimony were clearly probative because they linked Defendant to the crimes committed upon Hertz. Although we agree that the aura of infallibility surrounding DNA evidence does present the possibility of a decision based on the perceived infallibility of the evidence, we conclude that the damaging nature of the DNA evidence and the potential prejudice caused by this evidence does not require exclusion. We have already concluded that the FBI's procedures met the requirements of Rules 702 and 703. Defendant had the opportunity to vigorously cross-examine the State's experts and to present his own rebuttal expert witnesses to demonstrate why the results were unreliable, the procedures flawed, and the evidence not infallible. These are "the traditional and appropriate means of attacking shaky but admissible evidence." **Daubert,** 113 S. Ct. at 2798. The trial court did not abuse its discretion in concluding that the probative value of the DNA evidence was not substantially outweighed by any unfair prejudicial effect.

E. The NRC Report

{64} The NRC report was published in 1992 (two years after the **Frye** hearing in this case). We do not impute knowledge of this report's recommendations to the trial judge because it was not available to him or to the experts. The recommendations set out in the report, however, are recognized throughout the forensic scientific community and by various jurisdictions. We find the report persuasive and would like to see DNA typing in this state performed with the report's guidelines in mind, specifically the "ceiling principle" approach. This approach calculates the chance of a random match in a manner that takes into account the criticisms leveled by opponents of the FBI's methodology, most notably the possibility of population substructuring. The approach eliminates ethnicity as a factor in the calculation process and allows the use of the product rule while ensuring that probability estimates are appropriately conservative.

{65} Since the ceiling principle may not be used until the proper population sampling is computed, a "modified ceiling principle" approach has been formulated by the Committee on DNA Technology in Forensic Science which is, in effect, "a more conservative version of the conservative ceiling principle." **Porter,** 618 A.2d at 643. The modified ceiling principle may be utilized immediately because the frequencies are taken from existing databases. The Committee has concluded that when a particular statistical methodology or estimate is called into question, "the solution . . . is not to bar DNA evidence, but to ensure that estimates of the probability that a match between a

person's DNA and evidence DNA could occur by chance are appropriately conservative." NRC report at 134. We agree and approve of the NRC report's recommendation that the interim modified ceiling method be utilized until proper population sampling has been computed.

VI. CONCLUSION

{66} In conclusion, we hold that the trial court did not abuse its discretion in concluding that the DNA typing evidence and the accompanying statistical calculations in this case were *{*303}* admissible.[7] Any controversy over the results of the testing and the statistical calculations goes to the weight of the evidence and is properly left to the trier of fact. Accordingly, we reverse the Court of Appeals and affirm the trial court.

{67} IT IS SO ORDERED.

JOSEPH F. BACA, Justice

WE CONCUR:

GENE E. FRANCHINI, Justice

STANLEY F. FROST, Justice

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1 We do not consider Defendant's claim that the trial court abused its discretion by failing to consider his motions for reconsideration. We agree with the State that this issue was not properly presented to this Court on appeal as Defendant did not file a petition for writ of certiorari on this issue. Only the State filed a petition and we will consider only the issues raised by the State's petition. SCRA 1986, 12-502(C)(2) (Repl. Pamp. 1992).

2 We are aware that DNA typing is commonly referred to as "DNA fingerprinting." Although the term "DNA fingerprinting" was not used in this case, we find the use of this term unfortunate and reject its use in describing DNA profiling evidence because it implies that DNA typing evidence is conclusive. DNA typing evidence is never conclusive because the technology currently available can only determine if the contributor of the known sample could have contributed the unknown (or "evidentiary") sample. The closest science can come, at this point, to determining whether two pieces of DNA match is to make a statistical calculation that the "match" is only a random match.

3 Concluding that the two samples "match" is not the end of the procedure. "A DNA match merely tells the scientist that the person who contributed the known sample is a potential contributor of the unknown sample. The second step of the DNA identification

process then involves a determination of the probability that someone other than the contributor of the known sample could have contributed the unknown sample." **United States v. Martinez,** 3 F.3d 1191, 1194 (8th Cir. 1993), **cert. denied,** 126 L. Ed. 2d 697, 114 S. Ct. 734 (1994).

4 **Alberico** was decided after the hearing conducted in this case. At the time the **Frye** hearing was held, **Frye** was still the controlling law in New Mexico for the admission of novel scientific evidence.

5 Dr. Mueller explained "genetic drift" as follows:

Well, all biological populations, including humans, are finite in size. That is, there's a fixed number of individuals that every generation mate and produce the next generation of offspring.

Now, because of the finite nature of the individuals involved in the mating process, the actual transmission of genetic material from one generation to the next will have with it some kind of sampling variation that's reflected in the finite size of the population.

It's just as if you took a coin which comes up heads half the time and you only flipped it four times. It's very likely that you wouldn't get exactly two heads and two tails. You could get some other combination. The same happens for the transmission of genes. Finite numbers of individuals that take place in reproduction can cause changes in the actual numbers in the next generation.

6 That is, the articles were not sent to a publication where manuscripts are "reviewed by outside experts selected by that journal and the experts criticize the article and send the author their comments." **Bonds,** 12 F.3d at 559 n. 16.

7 This does not mean that DNA typing evidence should always be admitted into evidence. The admissibility of any such evidence remains subject to attack. Issues pertaining to relevancy or prejudice may be raised. In addition, traditional challenges to the admissibility of evidence such as improper procedures, contamination of the sample, or chain of custody questions may be presented. The evidence, in the above instances, may be found to be so tainted that it is totally unreliable and, therefore, must be excluded.