Louis PRATER *v.* STATE of Arkansas

CR 91-115 820 S.W.2d 429

Supreme Court of Arkansas
Opinion delivered November 11, 1991

1. EVIDENCE — ADMISSIBILITY OF NOVEL SCIENTIFIC EVIDENCE — RELEVANCY STANDARD ADOPTED. — The relevancy standard, requiring that the trial court conduct a preliminary inquiry that must focus on (1) the reliability of the novel process used to generate the evidence, (2) the possibility that admitting the evidence would overwhelm, confuse, or mislead the jury, and (3) the connection between the novel-process evidence to be offered and the disputed factual issues in the particular case, was adopted to determine the admissibility of novel scientific evidence.
2. EVIDENCE — NOVEL SCIENTIFIC EVIDENCE — RELEVANCY STANDARD — RELIABILITY CRITICAL. — Under the relevancy approach, reliability is the critical element.
3. EVIDENCE — NOVEL SCIENTIFIC EVIDENCE — RELEVANCY STAN-

DARD — FACTORS TO CONSIDER. — The referendum by the scientific community to determine the reliability of the technique, which is permitted but not required by the relevancy standard, will many times determine the issue; however, the courts may look to a number of other factors bearing on reliability including the novelty of the new technique, its relationship to more established modes of scientific analysis, the existence of specialized literature dealing with the technique, the qualifications and professional stature of expert witnesses, the non-judicial uses to which the scientific techniques are put, the frequency of erroneous results produced by the novel scientific technique, the type of error that could occur, and the proof of the use of the correct protocol during the specific test.

4. EVIDENCE — NOVEL SCIENTIFIC EVIDENCE — MATHEMATICAL PROBABILITIES ARISING FROM THAT EVIDENCE — PRELIMINARY DETERMINATION OF THE RELIABILITY OF THE PROCESS USED TO CALCULATE PROBABILITIES IS REQUIRED. — When a proponent of scientific evidence seeks to have admitted not only novel scientific evidence, but seeks to have admitted the mathematical probabilities arising from that scientific evidence, the trial judge must also make a preliminary determination of the reliability of the process used to calculate those probabilities, including such things as population databases that are used in "arriving at" or "determining" such probabilities, before allowing an expert to extrapolate calculations as to the probabilities in a particular case.

5. EVIDENCE — NOVEL SCIENTIFIC EVIDENCE — PROPONENT MUST MAKE INITIAL SHOWING OF RELIABILITY OF EVIDENCE AND UNDERLYING PROCESS. — Novel scientific evidence coupled with evidence of mathematical probabilities should be admitted only when the proponent of that evidence makes a preliminary showing of reliability of both the novel scientific evidence and of the process underlying the calculations.

6. EVIDENCE — NOVEL SCIENTIFIC EVIDENCE — OPPONENT MAY ATTACK THE RELIABILITY WITH HIS OWN EXPERTS. — The opponent of the evidence may cross-examine and attack the showing of reliability with his own experts at the preliminary hearing, and if the evidence is determined to be reliable and admissible, the opponent may, after its admission at trial, cross-examine or directly attack the evidence since the jury must determine the weight and credibility to be given it.

7. EVIDENCE — NOVEL SCIENTIFIC EVIDENCE — COURT MUST WEIGH DANGER THAT EVIDENCE MIGHT CONFUSE OR MISLEAD THE JURY. — After assessing the reliability of the evidence, the trial court must also weigh any danger that the evidence might confuse or mislead the jury, keeping in mind the "presumption of helpfulness" ac-

corded expert testimony generally under A.R.E. Rule 702, and that the relevancy approach favors admissibility whenever the general conditions for admissibility of evidence have been met.

8. EVIDENCE — NOVEL SCIENTIFIC EVIDENCE — PROPONENT'S BURDEN — OPPONENT'S OBJECTIONS. — Under the relevancy approach, the proponent of the evidence must first prove that it is reliable and will not confuse or mislead the jury; then if the court rules that it is admissible under A.R.E. Rule 702, the opponent of the evidence might then object to it on the basis that its probative value is outweighed by unfair prejudice, or it is a waste of time, or it is needless presentation of cumulative evidence under A.R.E. Rule 403.
9. EVIDENCE — NOVEL SCIENTIFIC EVIDENCE — FAILURE TO PROVE EXPERT TESTIMONY IS RELEVANT AND HELPFUL. — The proponent of the evidence must show the trial court precisely how the expert's testimony is relevant and helpful to the case, and failure to make this proof is a sufficient ground to exclude the evidence.
10. EVIDENCE — DNA TESTING SUFFICIENTLY RELIABLE PROCEDURE TO BE ADMITTED INTO EVIDENCE. — The ruling that the DNA testing was a sufficiently reliable scientific procedure that it was admitted into evidence was affirmed.
11. EVIDENCE — PROTOCOL FOR DNA TESTING WAS RELIABLE. — The DNA testing protocol was shown to be sufficiently reliable where the supervisory special agent with the FBI, a Ph.D. in organic chemistry, testified that he used the proper protocol and testified concerning the quality control steps and in-house proficiency testing used by the FBI in its DNA analysis unit; where two experts in biochemistry and molecular biology from the University of Arkansas for Medical Sciences testified to the reliability of the FBI's methodology; and where appellant's expert in biochemistry and molecular biology from the same university testified that she could detect no human error and that the samples were handled correctly.
12. EVIDENCE — DNA TESTING — RELIABILITY OF THE INTERPRETATION OF THE RESULTS. — The admissibility of expert testimony rests on the broad discretion of the trial court, and it did not abuse its discretion in ruling that the protocol used in administering this test was reliable and that the interpretations were sufficiently reliable to be admitted in evidence where the trial court heard the testimony of the FBI's expert that one probe was inconclusive, two showed matches of the upper bands, and the fourth probe, after reprobing with a longer radiation exposure, was a match of both the upper and lower bands; appellant's expert who testified that she found only one clear match of the upper bands, but that she could understand how

others would see them as matches; and the rebuttal of two other experts supporting the interpretation made by the FBI's expert.

13. EVIDENCE — DNA TESTING ADMISSIBLE WITHOUT DRAWING STATISTICAL INFERENCES. — Evidence of a DNA match made by a scientist who followed the proper laboratory protocol is admissible without drawing any statistical inferences.
14. EVIDENCE — CALCULATIONS AS TO PROBABILITIES BASED ON POPULATION GENETICS ARE RELEVANT AND HELPFUL IF RELIABLE. — While calculations as to probabilities based on population genetics have been questioned, they are clearly relevant and, if proven reliable, would be helpful to a jury, particularly in a rape case where there were no witnesses other than the victim and the accused.
15. EVIDENCE — CALCULATIONS AS TO PROBABILITIES — NO ABUSE OF DISCRETION TO ADMIT INTO EVIDENCE. — The trial court did not abuse its discretion in admitting the calculations as to probabilities on the evidence presented; however, the population criterion against which DNA identification matches are declared is not a closed issue; just how small the sample population may be, how the sampling is done, and the assumptions that underlie the probability calculation from the sample may all be the subject of dispute.
16. EVIDENCE — DNA TESTS SHOULD NOT BE RULED ADMISSIBLE BEFORE THE ACCUSED'S EXPERT HAS HAD A CHANCE TO EXAMINE THE EVIDENCE, PROCEDURES, AND PROTOCOL. — An accused must be given the opportunity for independent expert review before a determination of reliability is made; ideally, an accused should be provided with the actual DNA samples in order to reproduce the tests, but where this is not practical because the samples were so small that the entire sample was used in the proponent's testing of the evidence, access to data, methodology, and actual results are crucial.
17. EVIDENCE — DNA TEST RULED ADMISSIBLE — ACCUSED PROVIDED WITH EXPERT — NO PREJUDICE SHOWN. — Where the DNA tests were ruled admissible before appellant was provided with an expert to testify about the tests, but where no prejudice was shown to have resulted from the expert's late appointment, the judgment of conviction was not reversed.
18. CRIMINAL LAW — RAPE — SUFFICIENCY OF THE EVIDENCE — TESTIMONY OF VICTIM SUFFICIENT. — The testimony of the rape victim satisfies the substantial evidence requirement in a rape case and is thus sufficient to support the verdict.
19. WITNESSES — CREDIBILITY FOR THE JURY. — The credibility of witnesses is the province of the jury.

Appeal from Pulaski Circuit Court, Fifth Division; *Jack*

Lessenberry, Judge; affirmed.

William R. Simpson, Jr., Public Defender, *Andy O. Shaw*, Deputy Public Defender, by: *Andy O. Shaw*, Deputy Public Defender, for appellant.

Winston Bryant, Att'y Gen., by: *Clint Miller*, Senior Asst. Att'y Gen., for appellee.

ROBERT H. DUDLEY, Justice. This case determines our standard for the admissibility of novel scientific evidence and the standard for the admissibility of calculations as to probabilities arising from that novel scientific evidence.

The prosecutrix, a seventeen-year-old girl, was raped in a laundromat in southwest Little Rock. She called the police. They quickly responded and began searching the area for the offender. After only a few minutes, the victim spotted the appellant and identified him as the man who had attacked her. He was arrested. She was taken to the University Hospital where her vagina was swabbed to collect samples of secretions. The swab samples, along with blood samples taken from both the prosecutrix and the appellant, were sent to the laboratory of the Federal Bureau of Investigation (FBI) in Washington, D.C. There, the FBI conducted deoxyribonucleic acid (DNA) print identification tests.

The State gave the appellant notice that, at trial, it would offer evidence to prove that appellant's DNA profile matched that found in the swab samples, and that it would offer evidence that the probability of selecting a person at random from an unrelated black population and getting the same profile was only 1 in 3,700. The appellant objected to the proposed evidence. A preliminary hearing was held, and the trial court ruled that the evidence was admissible. It was then admitted at trial, and the appellant was convicted. This court has taken the case as it involves a case of first impression involving a significant legal issue.

1. *THE STANDARD*

The majority approach for determining the admissibility of novel scientific evidence continues to be the test enunciated in *Frye* v. *United States*, 293 F. 1013 (D.C. Cir. 1923). Under that standard, courts admit novel scientific evidence only when the theory upon which the evidence is based has gained general

acceptance within the relevant scientific community. *Id.* at 1014. This court has never adopted the *Frye* standard even though we signaled it as "see" in a per curiam opinion. See *Dumond* v. *State*, 294 Ark. 379, 743 S.W.2d 779 (1988). Several states have rejected the *Frye* standard. In doing so the Supreme Court of Georgia wrote: "[T]he *Frye* rule of 'counting heads' in the scientific community is not an appropriate way to determine the admissibility of a scientific procedure. . . . The significant point is that the trial court makes this determination based on the evidence available to him rather than by simply calculating the consensus in the scientific community." *Caldwell* v. *State*, 260 Ga. 278, 285-86, 393 S.E.2d 436, 441 (1990).

A growing number of jurisdictions, now numbering about one-third, have adopted a more liberal standard of admissibility. Imwinkelried, *The Standard for Admitting Scientific Evidence: A Critique from the Perspective of Juror Psychology*, 28 Vill. L. Rev. 554, 557-59 (1983). This more liberal standard, and the one which we adopt, is based upon the relevancy approach of the Uniform Rules of Evidence. The pertinent rules are the following:

> A.R.E. Rule 401:
>
> *Definition of "relevant evidence".*—"Relevant 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.* [Emphasis added.]
>
> A.R.E. Rule 402:
>
> *Relevant evidence generally admissible—Irrelevant evidence inadmissible.—All relevant evidence is admissible,* except as otherwise provided by statute or by these rules or by other rules applicable in the courts of this State. Evidence which is not relevant is not admissible. [Emphasis added.]
>
> A.R.E. Rule 702:
>
> *Testimony by experts.—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, experi-

ence, training, or education, may testify thereto in the form of an opinion or otherwise. [Emphasis added.]

[1] The relevancy approach requires that the trial court conduct a preliminary inquiry which must focus on (1) the reliability of the novel process used to generate the evidence, (2) the possibility that admitting the evidence would overwhelm, confuse or mislead the jury, and (3) the connection between the novel process evidence to be offered and the disputed factual issues in the particular case. *See* 3 J. Weinstein & M. Berger, *Weinstein's Evidence* ¶ 702[03] at 702-18 to 702-20 (1991).

A. *RELIABILITY*

[2, 3] Under this relevancy approach, reliability is the critical element. See *United States* v. *Downing*, 753 F.2d 1224, 1238 (3d Cir. 1985) for a list of cases so holding. The relevancy approach, unlike the *Frye* standard, permits, but does not require, a referendum by the relevant scientific community to determine the reliability of the technique. Many times that factor alone will determine the issue. On the other hand, courts may look to a number of other factors which bear upon reliability. These include the novelty of the new technique, its relationship to more established modes of scientific analysis, the existence of specialized literature dealing with the technique, the qualifications and professional stature of expert witnesses, and the non-judicial uses to which the scientific techniques are put. *Andrews* v. *State*, 533 So. 2d 841 (Fla. Dist. Ct. App. 1988) (citing *United States* v. *Downing*, 753 F.2d at 1238-39, and Weinstein & Berger, *supra*, at ¶ 702[03]).

The frequency of erroneous results produced by a novel scientific technique is an important component of reliability. At one extreme, a technique which yields erroneous results more often than correct ones would be of no value to the trier of fact. At the other extreme, a technique which is always correct would be of significant value. In addition to the rate of error, the trial court might examine the type of error which could occur.

Another important component of the reliability of scientific evidence is proof of the use of the correct protocol during the specific test. This proof is fundamental to the question of reliability. To illustrate, we quote from 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, 25:

> When the issue, however, is the trustworthiness of scientific evidence, courts generally cannot dismiss the possibility of error as purely theoretical or minimal. Studies have established impressive evidence of a substantial error margin in contemporary laboratory analysis. In the 1950s the American Academy of Forensic Sciences' Toxicology Section conducted a study of the accuracy of blood alcohol analyses. That study unearthed indications of "a great degree of error." In the mid-1970s, Dinovo and Gottschalk undertook to evaluate the proficiency of laboratories conducting drug analyses. They too reported significant variations in the level of proficiency from laboratory to laboratory.
>
> Later in the same decade the Law Enforcement Assistance Administration funded a much larger test, the Laboratory Proficiency Testing Program. Two hundred and forty laboratories participated. The researchers sent the participating laboratories twenty-one sets of blind samples for analysis. On three of the twenty-one sets, fewer than half the participating laboratories reported correct, complete findings. One of the lead researchers reluctantly concluded that the tests demonstrated that "a disturbingly high percentage of laboratories are not performing routine tests competently. . . ."
>
> In the early 1980s, other researchers administered a proficiency test to 105 toxicology laboratories in forty-nine states. Like the Laboratory Proficiency Testing Program researchers, these researchers found the laboratories' performance "disappointing." They discovered "considerable" variation in proficiency, especially in quantitative analysis. On some samples, the coefficient of variation was 133 percent.
>
> In the mid 1980s, several organizations published proficiency studies of laboratories conducting immunoassay tests to detect the presence of contraband drugs in

> urine samples. The studies were conducted under the auspices of such respected organizations as the College of American Pathologists. Two researchers for the Office of Technology Assessment of the United States Congress bluntly summarized the studies by generalizing that "error rates continue to be high." A study conducted by the Centers for Disease Control yielded particularly disturbing findings. One laboratory reported erroneous results on 66.5 percent of 160 samples analyzed.
>
> In 1987, Collaborative Testing Services made public the results of a proficiency test of laboratories engaged in electrophoretic analysis of enzymes and proteins. Sixty-eight laboratories participated in the test. Sixteen of the laboratories (23.5%) erred on one or both samples.
>
> More recently, the Forensic Science Foundation released the results of proficiency tests of document examiners. Like the studies described in the preceding paragraphs, these tests disclosed an alarmingly high incidence of misanalysis. The percentages of error were in the double figures. The incidence of error was so high that it "should provide anyone with cause for concern."
>
> In sum, extensive hard evidence exists of a substantial margin of error in modern forensic analysis. When an opposing party points to a brief gap in chain of custody to challenge the trustworthiness of an item of physical evidence, a court plausibly can dismiss the challenge as raising only theoretical risks of error. However, when the challenge is directed at a forensic laboratory analysis, the court cannot reject the challenge summarily. [Footnotes omitted.]

The lengthy quotation is set out to impress upon the trial judge his or her heavy responsibility in determining whether the correct protocol was followed in the particular test at issue. If the laboratory that performed the test did not follow reliable procedures to ensure accurate test results, the test should not be admitted. *State* v. *Schwartz*, 447 N.W.2d 422 (Minn. 1989). As one court aptly wrote, "[W]e are not, at this juncture, holding that DNA fingerprinting is now admissible willy-nilly." *Cobey* v. *State*, 80 Md. App. 31, 43, 559 A.2d 391, 398 (Md. Ct. Spec.

App. 1989).

[4] When a proponent of scientific evidence seeks to have admitted not only novel scientific evidence, but, in addition, seeks to have admitted the mathematical probabilities arising from that scientific evidence, the trial judge must also make a preliminary determination of the reliability of the process used to calculate those probabilities. To illustrate this type of evidence, we quote from a paragraph from the case of *State* v. *Brown*, 470 N.W.2d 30, 31 (Iowa 1991):

> In this case, four "fragments" of Brown's known DNA samples were matched with four fragments of the crime scene DNA. The probability of an individual possessing the particular genetic pattern for those four segments were, respectively, one in 25,094; one in 441; one in sixty; and one in 194. When these figures are combined, the likelihood of a person matching in all four fragments, according to the State's expert, would be one in several billion.

Under the standard we adopt, a trial judge would have to make a preliminary determination of the reliability of such things as population genetics databases which are used in calculating such probabilities before allowing an expert to extrapolate calculations as to the probabilities in a particular case. Again, this determination places a heavy responsibility upon the trial judge.

[5, 6] In sum, novel scientific evidence coupled with evidence of mathematical probabilities should be admitted only when the proponent of that evidence makes a preliminary showing of reliability of both the novel scientific evidence and of the process underlying the calculations. The opponent of the evidence may cross-examine and attack the showing of reliability with his own experts at the preliminary hearing. If the evidence is determined to be reliable and admissible, the opponent may, after its admission at trial, cross-examine or directly attack the evidence since the jury must determine the weight and credibility to be given it.

B. *NOT MISLEADING*

[7] After assessing the reliability of the evidence, the trial court must also weigh any danger that the evidence might confuse

or mislead the jury. The danger that scientific evidence will mislead the jury may be the greatest where the jury is not presented the data on which the expert relies, but instead, must accept the expert's assertions as to the accuracy of his conclusions. *See United States* v. *Downing*, 753 F.2d at 1239 (citing Weinstein and Berger, *supra*, 702[03] at 702-20 n. 18). The trial court must then weigh its assessment of the reliability of the novel scientific evidence against the danger that the evidence, even though reliable, might nonetheless confuse or mislead the finder of fact. In that weighing process, the trial judge must keep in mind the "presumption of helpfulness" accorded expert testimony generally under A.R.E. Rule 702. "The relevancy approach favors admissibility whenever the general conditions for admissibility of evidence have been met." Weinstein and Berger, *supra*, ¶ 702[03] at 702-21.

[8] This Rule 702 determination of whether the evidence might confuse or mislead the jury is separate from a Rule 403 weighing. Under the relevancy approach, the proponent of the evidence must first prove that it is reliable and will not confuse or mislead the jury. If the court rules that it is admissible under Rule 702, the opponent of the evidence might then object to it on the basis that its probative value is outweighed by unfair prejudice, or it is a waste of time, or it is needless presentation of cumulative evidence. A.R.E. Rule 403.

C. *HELPFUL*

[9] The third general consideration under the Rule 702 relevancy analysis is whether the proposed expert testimony is sufficiently tied to the facts of the case to aid the trier of fact in resolving the dispute. The proponent of the evidence must show the trial court precisely how the expert's testimony is relevant and helpful to the case. Failure to make this proof is a sufficient ground to exclude the evidence. *United States* v. *Downing*, 753 F.2d at 1242 (citing *United States* v. *Fosher*, 590 F.2d 381, 383 (1st Cir. 1979)).

II. *FACTS OF THIS CASE*

A. *DNA IDENTIFICATION*

The evidence in this case and the holding of cases from other jurisdictions clearly establish that the procedures involved in DNA profile analysis have been widely used in laboratories for research and diagnostic purposes for many years. It is only the transfer of this technology to a forensic setting which has recently occurred.

The background of DNA identification is set out below. The background information is taken from the testimony in this case and the following articles: Burk, *DNA Identification Possibilities & Pitfalls Revisited*, 31 Jurimetrics J. 53 (1990); Imwinkelreid, *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*, 18 Wash. U. L.Q. 19 (1991); Moenssens, *DNA Evidence And Its Critics - How Valid Are Challenges?*, 31 Jurimetrics J. 97 (1990); Thompson & Ford, *DNA Typing: Acceptance And Weight Of The New Genetic Identification Tests*, 75 Va. L. Rev. 45 (1989); Note, *Evidence Of DNA Fingerprinting Admitted For Identification Purposes In Rape Trial*, 12 U. Ark. Little Rock L.J. 543 (1989-90).

In the early 1800's scientists started to look inside the cell and learned that it had a nucleus. In the 1860's scientists identified chromosomes, which are rodlike bodies within the nucleus, and then they were able to distinguish individual chromosomes within a cell by their size and shape. As research progressed, scientists discovered that there are forty-six (46) chromosomes in each ordinary human cell. The Austrian monk Gregor Mendel manipulated pea nuclei and established that traits such as color and shape are controlled by heredity factors; these factors came to be called genes, which are specific regions on the chromosomes. Continuing to push forward the limits of human knowledge, other scientists discovered a substance that was called deoxyribonucleic acid, DNA, which is the building block of chromosomes, and thus the basic genetic material.

In 1953, two (2) scientists, Watson and Crick, discovered the exact nature of DNA, which they described as a double helix. The experts in this case, and some courts, have described DNA as

appearing like a spiral staircase. Research continued as scientists attempted to discover the components of the DNA molecule and began to unravel the basic genetic code within the strands of DNA. It was learned that the DNA strands are composed of four (4) nucleotide bases. These bases pair up, or hybridize, in certain ways to form the DNA molecule. The sequence of the bases along the strand determine the message the DNA carries.

It was then discovered that there are certain enzymes that cut DNA at very specific sites, or loci, on a strand. These findings ultimately led to the discovery of DNA probes, which are produced by recombinant DNA techniques. A DNA probe is simply a single strand of DNA which will attach to another strand of DNA when it finds a complimentary sequence. These probes were first used for diagnosis of genetic diseases, and later to look for DNA sequences that differentiate each individual. The research also established that the DNA in every cell of an individual is the same and remains so during the lifetime of that individual, at least in a general sense. Finally, it has been postulated, and this has not been disproven to date, that the DNA of one person is different from the DNA of all other people, with the exception of identical twins.

DNA testing does not evaluate all of the genetic information carried by a person's DNA. Rather, the tests identify variations in the structure of the DNA molecule. These structural variations are revealed by cutting DNA strands into pieces with restriction enzymes that break the DNA only at certain recognition sites. The recognition sites may be absent in some people; the uncut region of DNA from such a person will be longer than that from persons who have the recognition site. These variations of DNA fragments are called restriction fragment length polymorphisms, or RFLPs.

In order to visualize these characteristic fragment variations, the DNA fragments are separated on the basis of size. Native DNA exists as an intertwined double helix of two strands of nucleotide bases; these are separated into single strands which are cut by restriction enzymes, and the DNA fragments are placed into wells cut at one end of an agarose gel. The gel looks something like a slab of grey gelatin. When an electric current is applied, the pull of the current causes the electrically charged

DNA fragments to move through the gel. The smaller fragments move more quickly through the gel than do the larger fragments. This migration, by size, in the direction of the current creates lanes of DNA with different sized fragments separated into bands. This process is known as electrophoresis.

For the ease of handling, the bands are transferred to a filter through a process called Southern blotting; if the blotting process is done properly, the fragment bands on the filter will occupy the same positions as they did in the gel. The bands are then visualized through the use of a radioactive DNA probe that binds to an RFLP fragment of interest. Probes may be single-locus, identifying only a single band at a time, or they may be multilocus, identifying many RFLPs simultaneously. Photographic film is then placed next to the filter, and the radioactive probe will expose the film at the location of the DNA fragments which have hybridized with the probe, creating an autoradiograph that reveals the positions of the RFLP bands.

The banding pattern revealed by the autoradiographic patterns indicates the RFLPs carried by the particular person. Because these characteristics are inherited, they can be used to show relatedness, which has led to the use of such tests in paternity cases. *See* Ark. Code Ann. § 9-10-108 (Supp. 1991). RFLP banding may also be used to link suspects with materials from the scene of the crime, or as was done in this case, link the appellant with the crime by linking his RFLPs with those in the DNA found in the victim's vagina.

The interpretation of the autoradiographs to determine if the band patterns from the known and unknown samples match is conducted as follows: Assuming the autoradiographs produce banding patterns suitable for comparison, the examiner first determines whether a match may be called by visually comparing the bands. If the bands in the lanes containing the known DNA and the unknown DNA do not align with each other, they are declared not to match, and the examiner then determines whether the non-match should be interpreted as inconclusive or as excluding the donor of the known sample as a possible donor of the DNA in the questioned sample.

If the donor of the known sample is not excluded, a computerized measurement is made by comparing the bands

from the known sample and the questioned specimen to the size markers located on the autoradiograph. This comparison allows the examiner to extrapolate the length (the number of base pairs) of the bands of DNA from the evidentiary samples. If the bands from the known and questioned samples otherwise appear to be consistent, they are said to match if they fall within a "match window" of +/- 2.5% of the band's size.

The following courts have held DNA testing is admissible as forensic evidence under the *Frye* standard: *Smith* v. *Deppish*, 248 Kan. 217, 807 P.2d 144 (1991); *State* v. *Schwartz*, 447 N.W.2d 422 (Minn. 1989); *State* v. *Davis*, No. 71694, 1991 WL 134460 (Mo. July 23, 1991); *State* v. *Ford*, 392 S.E.2d 781 (S.C. 1990); *Glover* v. *State*, 787 S.W.2d 544 (Tex. Ct. App. 1990); *State* v. *Woodall*, 385 S.E.2d 253 (W. Va. 1989).

DNA profiling has been upheld under relevancy standards such as ours. See *Andrews* v. *State*, 533 So. 2d 841 (Fla. Dist. Ct. App. 1988); *Caldwell* v. *State*, 260 Ga. 278, 393 S.E.2d 436 (1990); *State* v. *Brown*, 470 N.W.2d 30 (Iowa 1991); *Spencer* v. *Commonwealth*, 238 Va. 275, 384 S.E.2d 775 (1989). One state has taken judicial notice of DNA typing reliability. *State* v. *Woodall*, 385 S.E.2d 253 (W. Va. 1989).

No court has held DNA profiling evidence to be inadmissible per se. A few courts have questioned the results in a particular case or in some way limited the testimony. *See State* v. *Schwartz*, *supra* (DNA evidence reliable only if performed in accordance with appropriate laboratory procedures); *State* v. *Woodall*, *supra* (DNA profiling reliable but test results not admitted because inconclusive); *People* v. *Castro*, 144 Misc. 2d 956, 545 N.Y.S.2d 988 (N.Y. Sup. Ct. 1989) (evidence of inclusion inadmissible because of failure of testing lab to use generally accepted scientific techniques).

[10] In sum, we have no hesitancy in affirming the trial court's ruling that DNA testing is such a sufficiently reliable scientific procedure that it may be admitted in evidence. The issue then becomes whether the laboratory protocol was shown to be reliable.

Harold Deadman, a Ph.D. in organic chemistry, a supervisory special agent with the FBI, and a member of the DNA

analysis unit testified that he used proper protocol in conducting the analysis. He additionally testified to the quality control steps and the in-house proficiency testing which the FBI uses in its DNA analysis unit.

Dr. James Hardin, an associate professor of medicine, biochemistry, and molecular biology at the University of Arkansas for Medical Sciences, and associate director of research at the Arkansas Cancer Research Center, testified that the FBI's testing procedures were "very reliable, very conservative, and very well settled." He further testified that he was familiar with the correct protocol from his years of experience in a molecular biology laboratory. Dr. Gary Bannon, assistant professor in the Department of Biochemistry and Molecular Biology at the University of Arkansas for Medical Sciences, testified the FBI's methodology was "very reliable."

The appellant's expert witness, Dr. Helen Benes, assistant professor in the Department of Biochemistry and Molecular Biology at the University of Arkansas for Medical Sciences, agreed with the protocol followed and testified:

> In my examination of Doctor Deadman's notes that he sent to me I could basically detect no human error. I believe that the sample was handled appropriately, that the DNA was extracted appropriately, that the distinction between the male and female DNA was also done appropriately and I have some disagreement with or inconsistencies with some of the numbers, but that we'll come to later, but I do not believe that they have anything to do with human error and I'm sure that Doctor Deadman can explain these. The interpretation of the DNA patterns I am essentially with the DNA patterns. I will tell you that when Doctor says that there is a band I also believe that there is a band. When Doctor Deadman says that there is no band present I also find no band present. The opposite you might consider if he claims there is a band I agree with that. He makes no claims to a band that I do not see. So we are basically in agreement with that aspect of the analysis.

[11] The protocol was thus shown to be sufficiently reliable. The examination then shifts to determining the reliability of the interpretation of the autoradiographic patterns. Dr. Deadman

first testified about the banding revealed by the autoradiographs. He testified that he ran four (4) probes in this case. One (1) was inconclusive. Two (2) showed that the upper bands from the sample taken from the victim's vagina were consistent with the upper bands of the samples taken from the appellant. On the fourth probe, Dr. Deadman, at first, could not get a banding pattern due to the insufficiency of the sample, but, by reprobing with a longer radiation exposure, was able to declare a match of both the upper and lower bands.

The appellant's expert, Dr. Helen Benes, testified that there was only one (1) clear match of the upper bands; that two (2) of the others were unclear, although she could understand how others would see them as matches.

In rebuttal, the State then called Dr. Gary Bannon and Dr. Jim Hardin. They testified they did not agree with Dr. Benes's criticisms of Dr. Deadman's work and instead fully agreed with Dr. Deadman's matching of the bands.

[12] The evidence established that autoradiographs may sometimes be ambiguous or difficult to interpret and that the analyst can err in measuring the bands and in interpreting the results. Determining whether two (2) samples match can involve subjective judgement. Just as it is difficult to distinguish between two (2) individuals on the basis of blurry photographs, it may be difficult to distinguish between (2) different DNA types if the bands are unclear. A misidentification may occur if two (2) different types are mistaken for one another. The trial court, in deciding whether the testimony about matching of bands was reliable, considered the possibility of a mistake in the subjective judgment of the scientists. The trial court heard Dr. Deadman on the issue, heard Dr. Benes's criticisms of his judgment, and heard Drs. Bannon and Hardin's rebuttal. The admissibility of expert testimony rests on the broad discretion of the trial court, *Sims* v. *Safeway Trails, Inc.*, 297 Ark. 588, 764 S.W.2d 427 (1989), and we cannot say the trial court abused its discretion in ruling that the protocol used in administering this test was reliable and that the interpretations were sufficiently reliable to be admitted in evidence.

B. *EXTRAPOLATING CALCULATIONS AS TO PROBABILITIES*

[13] Evidence of a DNA match made by a scientist who followed the proper laboratory protocol is admissible without drawing any statistical inferences. The scientist could simply testify to having performed the necessary steps and having determined that the two (2) samples examined match. The next step of extrapolating calculations as to the probability of random matches is not an essential step to DNA identification testing but, because of its impact, the State sought to add it to the testimony.

These calculations, arrived at by using population genetics, have been questioned by at least three (3) courts and one commentator. The Supreme Court of Minnesota questioned its tendency to prejudice a jury and limited the use of such statistics. *See State* v. *Schwartz*, 447 N.W.2d 422 (Minn. 1989). As of 1989, nineteen (19) jurisdictions had refused to follow the reasoning of the *Schwartz* doctrine. *See State* v. *Schwartz*, 447 N.W.2d at 429 (Kelly, J., concurring). The Supreme Court of Alabama has also expressed concern over the potential tendency the statistics have to prejudice a jury. *See Ex parte Perry*, 586 So.2d 242 (Ala. 1991). In *Perry*, the court adopted an approach similar to the one we adopt in that they separated the determination of the reliability of the statistical population genetics portion of the analysis from the determination of the reliability of the DNA "matching" evidence. The Superior Court of the District of Columbia, criminal division, felony branch, in *United States* v. *Porter*, No. 706277-89, 1991 WL 319015 (D.C. Super. Sept. 20, 1991), in applying the *Frye* test, held that the government failed to demonstrate general acceptance within the scientific community of the calculations of probabilities. In addition, Dr. Eric Lander, a mathematician, has raised questions about the adequacy of existing population genetics databases which are used in calculating the probabilities. *See* Moenssens, *DNA Evidence And Its Critics - How Valid Are The Challenges?*, 31 Jurimetrics J. 97 (1990).

[14] While calculations as to probabilities based upon population genetics have been questioned, they are clearly relevant and, if proven to be reliable, would be helpful to a jury, particularly in rape cases such as this one where there are no

witnesses other than the victim and the accused. Thus, under our standard, if the extrapolations are reliable, they should be admitted in evidence.

Once two or more DNA patterns derived from loci that are known to be polymorphic (different among individuals) have been matched, the question arises whether this matching is coincidental. This is the point at which statistics begin to play a role.

In order to establish estimates of probability, the F.B.I. employs a technique called fixed bin analysis. This system is used to determine population allele frequencies and, in turn, to determine the frequency of an allele in an evidentiary sample. This approach is designed to compensate for the inability to precisely measure alleles.

First, the F.B.I. constructs tables of allele frequencies. In order to construct these tables, DNA profiles, using the same RFLP process and probes previously discussed, are run by the F.B.I. on a population. In this case, we are concerned only with the data from the black population since the appellant fits within that group. These blood samples come from studies at the Baylor University School of Medicine in Houston, Texas, from a crime laboratory in Dade County, Florida, and from the University of South Carolina Medical School in Charleston, South Carolina.

For each of the four (4) probes, the allele or alleles resulting from the profile are assigned to bins, a category of alleles which all fall within a predetermined size range defined by the size markers which are run with each DNA test. As to each probe, the frequency for each bin is calculated by dividing the total number of alleles falling within it by the total number of alleles resulting from the profiling of all the samples for that probe. The first size marker occurs at 640 base pairs; so the first bin, which is called bin 1, contains alleles measuring between 1 and 639 base pairs. The second category, or bin 2, contains alleles measuring between 640 and 672 base pairs, and so on through twenty (20) bins.

Once the frequencies of the bins are established for each probe, the tables of allele frequencies are used to determine the estimate of the probability that a person of the population relevant to the suspect, picked randomly, would have a DNA

profile matching the profile displayed by the DNA from the samples from the same population group.

The likelihood of a coincidental match decreases as the number of matching bands and the rarity of those bands increases. Suppose, for example, there is a matching of two (2) bands, one reflects a band found in 10% of the group's population and the other one reflects a band found in 50% of the group's population. An analyst would conclude that the probability of coincidental match is .10 X .50 = .05, or a 5% probability. This approach assumes that the probability of one band occurring does not affect the probability of any other band occurring. This assumption is valid only if the entire population being studied is in a condition known as Hardy-Weinberg Equilibrium. Dr. Deadman testified for the State that the population genetics were appropriate in every manner.

Dr. Benes, in testifying for the appellant, expressed concern that the database for black people was not representative of the population group at-large. She also expressed concern as to whether the databases were in Hardy-Weinberg Equilibrium.

Dr. Deadman and Dr. Jim Hardin testified in rebuttal that probabilities given in this case were "conservative." The significance of the "conservative" rebuttal testimony is that in the best known case on this subject, *People* v. *Castro*, 144 Misc. 2d 956, 545 N.Y.S.2d 985 (N.Y. Sup. Ct. 1989), the court, in quoting an expert on the issue, wrote: "Conservative or reduced calculations may also correct the Hardy-Weinberg deviation problems." *Id.* at 993, 545 N.Y.S.2d at 993.

[15] Upon reviewing the foregoing evidence we cannot say that the trial court abused its discretion in admitting the calculations as to probabilities. However, just because there was no meaningful attack upon the population genetics in this case does not mean that there can not be a successful attack in future cases. In fact, there was such a successful attack in the case of *United States* v. *Porter*, No. 706277-89 (D.C. Super. Ct., Sept. 20, 1991). Just how small the sample population may be, how the sampling is done, and the assumptions that underlie the probability calculation from the sample may all be the subject of dispute. In short, the population criterion against which DNA identification matches are declared is not a closed issue.

III. *APPOINTMENT OF EXPERT WITNESS*

The appellant was charged by information, made bond, was determined to be an indigent, and an attorney was appointed for him. He stood trial on October 26 and 27, 1989 and, at that trial, challenged the admissibility of the DNA testing. The jury heard Dr. Deadman's testimony for the State on DNA testing. The presiding special judge ruled the DNA results were not admissible and declared a mistrial because the jury had heard the DNA-testing testimony.

The State gave notice that it intended to retry the appellant and asked for a rehearing on the admissibility of DNA profiling. The appellant asked for funds to employ an expert on DNA testing. Three (3) days later, on November 30, 1989, the regularly elected judge held a hearing and ruled that DNA testing was admissible but, because of a shortage of county funds, declined to appoint an expert in DNA analysis for the appellant. That ruling was in error.

[16] DNA tests should not be ruled admissible before the accused's expert has had a chance to examine the evidence, procedures, and protocol. Ideally, an accused should even be provided with the actual DNA samples in order to reproduce the tests. As a practical matter, this may not be possible because, as in this case, the samples were so small that the entire sample was used in the proponent's testing of the evidence. Consequently, access to data, methodology, and actual results are crucial. An accused must be given the opportunity for independent expert review before a determination of reliability is made.

[17] However, the regular trial judge subsequently ordered that funds be provided to employ an expert witness for the appellant. Appellant obtained the service of Dr. Benes. The State's data, including the autoradiographs, methodology, and results were supplied to the appellant's expert, Dr. Benes. She apparently had sufficient time to examine all of the materials. Later, at trial, the appellant's attorney used the materials to cross-examine the State's witnesses. Dr. Benes, a most competent witness, testified on direct examination in great detail about the specific nature of her disagreement with Dr. Deadman's interpretation of the DNA profile analysis. Given that the accused was afforded an expert to testify about these matters, and that the

accused has not shown any prejudice as a result of the expert's late appointment, we decline to reverse the judgment of conviction. We do not reverse for trial error in absence of prejudice. *Berna* v. *State*, 282 Ark. 563, 670 S.W.2d 434 (1984), *cert. denied*, 470 U.S. 1985 (1985).

IV. *SUFFICIENCY OF EVIDENCE*

[18, 19] The appellant's final argument is that the evidence is not sufficient to support the verdict. We treat the argument in summary fashion. On appeal, we review the evidence in the light most favorable to the appellee. *Jones* v. *State*, 297 Ark. 499, 763 S.W.2d 655 (1989). We affirm a conviction if substantial evidence exists to support it. Evidence is substantial if the jury could have reached its conclusion without having to resort to speculation or conjecture. *Id.* The testimony of the rape victim satisfies the substantial evidence requirement in a rape case. *Id.* The testimony of the prosecutrix alone is thus sufficient to support the verdict. Additionally, appellant attacks the prosecutrix's testimony. However,the credibility of witnesses is the province of the jury. We will not disturb the jury's judgment. *Taylor* v. *State*, 296 Ark. 89, 752 S.W.2d 2 (1988).

Affirmed.

BROWN, J., not participating.