

STATE OF MINNESOTA

IN SUPREME COURT

C6-01-244

Court of Appeals

Blatz, C.J.

Took no part, Hanson, J.

State of Minnesota, petitioner,

Appellant,

vs.

Filed: February 24, 2003

Office of Appellate Courts

Raymond Joseph Traylor,

Respondent.

S Y L L A B U S

1. District court correctly concluded that PCR-STR DNA testing is generally accepted in the relevant scientific community as required under the first prong of the *Frye-Mack* test.

2. District court did not abuse its discretion in concluding that the appropriate standards and controls currently in effect are the DAB standards and that the BCA complied with those standards.

3. Primer sequences and unlimited access to validation studies are not necessary for the scientific community to validate multiplex DNA kits and therefore defendant's due process right to a fair trial was not violated.

Affirmed.

Heard, considered, and decided by the court en banc.

OPINION

BLATZ, Chief Justice.

Appellant Raymond Joseph Traylor was convicted of second-degree assault and controlled substance possession in the fifth degree, in violation of Minn. Stat. §§ 609.222 and 152.025, subd. 2(1) (2002). In this appeal, Traylor contends that the district court erred in admitting deoxyribonucleic acid (DNA) evidence obtained by the Minnesota Bureau of Criminal Apprehension (BCA) via a new testing methodology. Traylor asserts that the BCA's current form of DNA testing does not meet this court's requirements for admissibility and reliability of evidence. At trial, the DNA evidence was admitted over Traylor's motion for suppression. Holding that the district court erred in its application of standards governing the admissibility of DNA evidence but that such error was harmless, the court of appeals affirmed Traylor's conviction. We reverse the court of appeals decision insofar as it held that the district court erred and affirm the conviction.

On November 13, 1999, Debra Clemons contacted the Minneapolis police and reported that she had been stabbed by Traylor, and that he was now asleep in her home. When police arrived, they found Traylor and arrested him. A small amount of cocaine was found on Traylor's person, and a bloody knife was found at the scene. The Minnesota Bureau of Criminal Apprehension subsequently performed DNA testing on the knife. Traylor challenged the district court's admission of the DNA evidence, asserting that the BCA's current method of DNA testing is a new, disputed technology. The district court held a *Frye-Mack* hearing, incorporating testimony from an earlier *Frye-Mack* hearing on the matter. The district court found the DNA evidence admissible, and ruled that the DNA Advisory Board (DAB) standards were the appropriate standards to govern the BCA's use of the new DNA testing methodology. The court

of appeals held that the quality assurance standards relied upon by the district court were not the standards previously adopted by this court and therefore the admission of the DNA evidence was error. *See State v. Traylor*, 641 N.W.2d 335, 340-41 (Minn. App. 2002).

However, the court of appeals affirmed Traylor's conviction and held that the error was harmless. *Id.* at 342. Both Traylor and the state cross-appealed to this court. The state contends that DNA testing as currently conducted by the BCA meets the *Frye-Mack* standard for the admissibility of scientific evidence and the court of appeals' reasoning in excluding the evidence was in error. Traylor, in turn, challenges the court of appeals decision that the error was harmless.

While the underlying science of DNA identification technology is not at issue here, a review of our prior case law as well as a brief discussion of the underlying science will be helpful in addressing the issues presented in this appeal. In *State v. Schwartz*, 447 N.W.2d 422, 425 (Minn. 1989), we explained the basic science of how DNA may be used for identification purposes:

DNA (deoxyribonucleic acid) is an extremely long, thread-like chain of molecules found in the nucleus of every cell in the body * * *. The DNA chains are tightly coiled up into bodies called "chromosomes," of which humans have twenty-three * * *. No two individuals, except for identical twins, have identical DNA. Within a given person, however, DNA does not vary from cell to cell. *Id.* (quoting William C. Thompson & Simon Ford, *DNA Typing: Acceptance and Weight of the New Genetic Identification Tests*, 75 Va. L. Rev. 45, 61 (1989)).

Early forensic DNA testing was performed using a method called Restricted Fragment Length Polymorphism testing (RFLP). This method has been accepted as reliable and accurate by this court. *See State v. Roman Nose*, 649 N.W.2d 815, 820 (Minn. 2002); *State v. Jobe*, 486 N.W.2d 407, 419-20 (Minn. 1992).

RFLP testing, however, is not without some limitations. Several witnesses at the *Frye-Mack* hearing below testified as to its disadvantages. Patricia Wojtowicz, supervisor of the biology section at the BCA, explained that because RFLP requires relatively large samples in order to work, it was unusable in situations where a smaller amount of bodily fluid was available. Ann Gross, a forensic scientist at the BCA who has performed many RFLP tests, noted that RFLP technology is not effective when working with degraded^[1] DNA samples. Finally, Wojtowicz indicated that because the RFLP alleles, the alternative form of the genes being examined, could not be sized exactly, the use of “bins” was required. “Binning,” the grouping of different sized alleles, is problematic because it decreases the accuracy of testing.

Since our decisions in *Schwartz* and *Jobe*, the FBI, in conjunction with state and local forensic laboratories, has created a computerized database of DNA profiles of known, convicted offenders and unknown forensic DNA samples. The Combined DNA Index System database, known as CODIS, allows law enforcement at all levels to compare DNA profiles electronically. CODIS initially used the RFLP methodology, but the disadvantages of that methodology proved limiting. Wojtowicz explained that the limitations led scientists to the “logical step” of development of new methods of DNA analysis that would avoid the pitfalls of RFLP. Two DNA-related options—Polymerase Chain Reaction and Short Tandem Repeats—were explored. Dr. Bruce Budowle, a senior scientist at the FBI and, at the time of the *Frye-Mack* hearing, the chair of the Scientific Working Group on DNA Analysis Methods, explained that PCR was explored because it was both “more sensitive” and allowed for a more easily automated procedure.

Polymerase Chain Reaction (PCR) is a method for replicating, also known as amplifying a portion of an individual’s DNA. It essentially copies DNA, thus increasing the amount

available to be tested. This method does not replicate the entire DNA strand. Instead, it generates millions of copies of a particular portion of DNA by repeatedly replicating a small, defined portion of the strand.

This replication is accomplished through the use of primers—small pieces of DNA that attach to a denatured single-stranded DNA and bracket specific genes in the DNA strand. The method is considered especially beneficial for forensic testing, as the replication allows for testing of both degraded DNA and small amounts of DNA. The BCA has used a type of PCR-based analysis since 1994.

To test only a portion of the DNA strand, as both PCR and RFLP methodologies do, the testing must focus on DNA that is unique to every individual. Dr. Budowle explained that while all humans share essentially the same genes, these genes are polymorphic, meaning they exist in different forms. It is the length of these polymorphic forms of genes that vary in size from person to person. Thus, determining the variation in length across a number of genes allows scientists to identify a person based on their DNA.

Recently, PCR testing began to examine a portion of human DNA known as short tandem repeats, or STRs. Both Dr. Budowle and Gross explained that every human has certain STRs, DNA in which a DNA sequence is repeated along the strand. However, because there is variation in the length of the STRs for each individual, examining a number of the STRs allows for identification. STRs are similar to the portion of DNA examined in RFLP testing, but the base pairs that are repeated are much smaller.

PCR-STR testing, or the testing of short tandem repeats via amplification of discrete portions of the DNA strand, came to prominence under the auspices of the FBI's STR Standardization Project. Wojtowicz explained that this project was a national effort of forensic

DNA laboratories to determine which STRs would be best suited for forensic DNA testing. Dr. P. Michael Conneally, Distinguished Professor of Medical Genetics at the Indiana University Medical Center and a member of the Human Genome Organization, further testified that the twelve STR markers eventually settled upon, and used by CODIS, the BCA, and the FBI, have been accepted by the Human Genome Organization. The Human Genome Organization, or HUGO, is a coordinated national effort to map all human genetic material by determining the complete sequence of the human DNA.

To perform PCR-STR amplification and analysis of DNA is a five-part procedure:

- 1) Extraction—the DNA is isolated from bodily fluids.
- 2) Quantitation—the amount of the isolated DNA is determined.
- 3) Amplification—portions of the DNA strand are copied repeatedly to produce sufficient material for testing, either by DNA sequence variation or DNA fragment length variation.
- 4) Electrophoresis—amplified pieces of DNA are separated based on size, along with an allelic ladder, which contains fragments of a known size for each loci examined, for comparison.
- 5) STR determination—the size of the DNA fragments are determined by comparing the stratified samples to the allelic ladders.

Several of these processes, including amplification, extraction, electrophoresis, and quantitation were used in previous methods of DNA analysis. When a known sample of bodily fluid is examined using these steps, the result can be compared with the result taken from an unknown forensic sample. Thus, it is possible to determine whether the samples are from the same source by determining if the size of the DNA fragments from both samples are identical.

Today, PCR-STR testing is often performed using kits. Kits enable the laboratory to perform tests on several STRs (from one person) simultaneously during one reaction. Such kits are known as multiplex kits. Because a multiplex kit performs all manipulations of the DNA at once, there is less risk of contamination than when the DNA is manipulated several times. In the interest of efficacy and uniformity, the STR Standardization Project chose to have multiplex kits developed and chose to automate analysis.

Early multiplex kits tested a relatively small number of markers, such as three. Defense experts agreed during the *Frye-Mack* hearings in this case that several older PCR-based multiplex kits have been validated and demonstrate that they can “yield reliable results in a forensic setting.” Some of these systems, like those at issue here, were commercially developed.

In 1994, the BCA first began using a PCR multiplex kit, known as the Polymarker, which enabled six markers to be typed in one test. The kit was developed by the Perkin-Elmer Corporation, which also manufactured the kits in this case. Wojtowicz estimates she personally used the Polymarker in over 100 cases at the BCA.

Dr. Budowle explained the process by which Perkin-Elmer became involved in the manufacturing of the kits at issue in this case. Perkin-Elmer had previously developed a triplex kit, known colloquially as the blue kit, that analyzed three genes. The FBI approached Perkin-Elmer and inquired as to whether it wished to be involved with developing a new kit for the STR Standardization Project. Perkin-Elmer initially declined, but later decided that it was interested in developing a kit. Promega, a competitor, also agreed to develop a new multiplex kit.

The members of the STR project worked closely with several companies during kit development. The FBI was not involved with the actual design of the primers, but did give the companies feedback on the primers following testing. After viewing portions of Perkins-Elmer’s developmental studies, the FBI then conducted its own internal validation studies. The purpose of the validation studies was to determine whether the manufacturers’ claims of performance were accurate. Individual laboratories, including the BCA, also conducted their own validation studies. Further, because the BCA was a member of the STR Standardization Project, it was a part of the entire process of developmental validation.

Today, the BCA uses two kits manufactured by Perkins-Elmer. These are known as Profiler Plus and Cofiler, and, as Wojtowicz explained, they meet the requirements established by the STR Standardization Project. The primers used in these kits, however, are proprietary, and information regarding the primers' composition was not available to anyone during the district court proceedings. The FBI also uses these kits, as do several other forensic laboratories in the United States. Perkin-Elmer's kits are comprised of earlier triplex kits, which were further developed and combined into the multiplex kit.

Forensic Scientist Gross explained that, while Profiler Plus examines nine STRs, Cofiler examines six. The kits are used in conjunction with one another. Two loci are common to both kits and act as a quality control mechanism. Gross further detailed BCA's quality control mechanisms, noting that a number of controls are built into the BCA procedures to minimize error. For each test, a second scientist who took part in the initial testing does an independent reading of the results.

I.

Traylor challenges the district court's admission of DNA evidence, contending that PCR-STR testing as currently performed by the BCA is a new, disputed technology. Specifically, Traylor asserts he was hampered by the commercial manufacturer's refusal to provide proprietary information regarding the multiplex kits.

The underlying science of using DNA as a forensic identification tool is not at issue here. We have already concluded that "DNA typing is generally acceptable." *State v. Schwartz*, 447 N.W.2d 422, 426 (Minn. 1989). A few years later, in *State v. Jobe*, 486 N.W.2d 407 (Minn. 1992), we explicitly emphasized, however, that our holding in *Schwartz* of general acceptance

was limited to the principles underlying RFLP testing. *Jobe*, 486 N.W.2d at 419-20. As such, this new testing methodology presents a question of first impression for us.

Particular scientific evidence must have a foundation that is scientifically reliable. *State v. Roman Nose*, 649 N.W.2d 815, 818 (Minn. 2000). In Minnesota, a two-pronged standard, known as *Frye-Mack*, must be satisfied before such evidence may be admitted:

First, a novel scientific technique that produces evidence to be admitted at trial must be shown to be generally accepted within the relevant scientific community, and second, the particular evidence derived from the technique and used in an individual case must have a foundation that is scientifically reliable. Put another way, the *Frye-Mack* standard asks first whether experts in the field widely share the view that the results of scientific testing are scientifically reliable, and second whether the laboratory conducting the tests in the individual case complied with appropriate standards and controls. *Roman Nose*, 649 N.W.2d at 818 (citations omitted).

This court has recently reaffirmed its commitment to the *Frye-Mack* standard, declaring it preferable to the federal *Daubert* standard. *Goeb v. Tharaldson*, 615 N.W.2d 800, 812-14 (Minn. 2000). The *Daubert* standard, modeled on Federal Rule of Evidence 702,^[2] contains no “general acceptance” requirement. *See State v. Roman Nose*, 649 N.W.2d at 819 n.2; *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 588 (1993) (noting that drafting history of Rule 702 makes no mention of *Frye* and that the “general acceptance” requirement is contrary to the general approach of the Federal Rules of Evidence).

A. General Acceptance

Requiring general acceptance confers a significant benefit on the district court. The general acceptance standard “ensures that the persons [namely, scientists] most qualified to assess scientific validity of a technique have the determinative voice.” *Goeb*, 615 N.W.2d at 813. Such an approach avoids the problem that many commentators see as inherent in *Daubert*, namely, that such an approach “takes from scientists and confers upon judges * * * the authority to determine what is scientific.” *Goeb*, 615 N.W.2d at 812. Finally, the *Daubert* approach, based

as it is upon the evidentiary discretion of the district court, allows only for an abuse of discretion review at the appellate level. See *General Electric Co. v. Joiner*, 522 U.S. 136, 142-43 (1997).

The *Frye-Mack* standard, in contrast, allows for more rigorous appellate review:

[U]nder the *Frye* prong of the *Frye-Mack* standard, the trial judge defers to the scientific community's assessment of a given technique, and the appellate court reviews de novo the legal determination of whether the scientific methodology has obtained general acceptance in the scientific community.

Goeb, 615 N.W.2d at 814.

Following the *Frye-Mack* hearing, the district court made the following relevant findings of fact:

§ the scientific basis and theory of DNA typing using the PCR methodology is not in dispute and is generally accepted in the scientific community.

§ PCR-STR typing involves generally accepted procedures.

§ the state must demonstrate general acceptance in the scientific community of the underlying method and theory behind PCR-STR typing, but the particular machine and kits only need to be shown to have been used in accordance with appropriate and accepted standards.

The question before this court, then, as framed by the district court, is whether forensic DNA typing using the PCR-STR methodology can be said to be generally accepted in the relevant scientific community.

During the *Frye-Mack* hearing, the state presented a wide range of information compelling the conclusion that this new methodology is widely accepted. The state offered a number of experts from outside of the forensic community. Dr. George Carmody, an expert who examines genetic variation across different populations, explained that he had worked with STRs for a number of years. Another expert, Dr. Michael Conneally, a member of the Human Genome Organization, declared PCR-STR technology superior to that of RFLP. Further, forensic experts presented by the state testified that PCR-STR testing is generally accepted in the forensic community.

A review of the scientific literature also supports the notion that PCR-STR technology has become widely accepted as a DNA typing tool. The state directs us to the online bibliography maintained by the National Institute of Standards and Technology.[\[3\]](#) The scientific literature discussed PCR technology as early as 1992.[\[4\]](#) A review of the National Institute of Standards and Technology bibliography seems to indicate that the first STRs were recognized and written about in the scientific literature in the early 1990s.[\[5\]](#) Today, there is extensive literature discussing STR testing, both as to its efficacy in forensic settings and for other identification purposes, such as paternity.[\[6\]](#)

The state also points out that a number of decisions from other appellate courts have addressed whether PCR-STR testing can be found to be generally accepted. At the outset, it is important to note that these courts often rely upon different, less rigorous evidentiary standards than those imposed by the *Frye-Mack* test. We discussed some of these decisions in our recent decision in *State v. Roman Nose*, 649 N.W.2d at 820. Moreover, in *Roman Nose*, we noted that while the decisions may be relevant evidence at the evidentiary hearing as to general acceptance, expert witness testimony at a *Frye-Mack* hearing was still necessary. *Roman Nose*, 649 N.W.2d at 820.

In the past, we have held that such evidence—expert testimony as to reliability and accuracy, the extent of the shared belief of the experts in that reliability, and decisions in other jurisdictions—was sufficient to warrant a holding of admissibility under the *Frye-Mack* standards. *See State v. Fenney*, 448 N.W.2d 54, 61 (Minn. 1989). This case, however, presents us with additional, unique problems. Traylor has expressed concern over the unavailability of the primer sequences in the kits. Traylor is further concerned that the standards currently governing forensic DNA testing are insufficient to guarantee reliability.

The bulk of Traylor’s concerns deal with reliability and are therefore more properly aligned with the second prong of the *Frye-Mack* analysis. As to the first prong of *Frye-Mack*—general acceptability—we hold that it is met by the evidence presented in this case. It is clear that PCR-STR technology, as a method of DNA typing for forensic identification, is generally accepted in the relevant scientific community.

B. Foundational Reliability

We next address whether the second prong of the *Frye-Mack* test—foundational reliability—is met. In *Schwartz*, this court noted that “[r]eliability is particularly important in a criminal proceeding because a suspect may face the loss of liberty due to DNA identification.” 447 N.W.2d at 426. Moreover, we recognized that “specific DNA test results are only as reliable and accurate as the testing procedures used by the particular laboratory.” *Id.* Thus, in determining the foundational reliability of a laboratory’s DNA testing methodology under the *Frye-Mack* standard, this court looks at “whether the laboratory conducting the tests in the individual case complied with appropriate standards and controls.” *Roman Nose*, 649 N.W.2d at 819.

In this case, the district court found that the standards of the DNA Advisory Board (DAB) have superseded the previously recognized Technical Working Group on DNA Analysis Methods (TWGDAM) guidelines and thus are the appropriate standards and controls a court should examine in determining foundational reliability. The court further concluded that the BCA was in full and total compliance with the DAB standards. We review the court’s determinations for abuse of discretion. *Goeb*, 615 N.W.2d at 815.

The first issue we must address is what are the “appropriate standards and controls” that a laboratory’s DNA testing must comply with in order to ensure reliable results. To begin our

examination, we review the purpose and history of the DAB standards and the older TWGDAM guidelines, which were the standards and procedures this court has looked to for guidance in past cases.

TWGDAM first met in November 1988 and consisted of 31 scientists from 16 forensic laboratories in the U.S. and Canada and two research institutions. The purpose of TWGDAM was:

- (1) to pull together a select number of individuals from the forensic science community who are actively pursuing the various DNA analysis methods;
- (2) to discuss the methods now being used;
- (3) to compare the work that has been done;
- (4) to share protocols; and
- (5) to establish guidelines where appropriate.

Technical Working Group on DNA Analysis Methods (TWGDAM) and California Association of Criminalists Ad Hoc Committee on DNA Quality Assurance, *Guidelines for a Quality Assurance Program for DNA Analysis*, 18 Crime Laboratory Digest, No. 2, 44, 46 (1991). At the group's first meeting, a subcommittee was formed to establish suggested guidelines for a quality assurance program in crime laboratories that were conducting RFLP DNA analysis. These guidelines, called the TWGDAM guidelines, were initially published in 1989 in the April-June issue of *Crime Laboratory Digest* and later supplemented in the July 1990 issue. In the introduction to its 1989 guidelines, TWGDAM noted that "[t]hese guidelines represent the minimum [quality assurance] requirements for DNA RFLP analysis and are intended to serve only as a guide to laboratory managers in establishing their own [quality assurance] program for DNA RFLP analysis." Technical Working Group on DNA Analysis Methods (TWGDAM) and California Association of Criminalists Ad Hoc Committee on DNA Quality Assurance, *Guidelines for a Quality Assurance Program for DNA Analysis*, 18 Crime Laboratory Digest, No. 2, 44, 46 (1991). TWGDAM also recognized that "[t]hese guidelines * * * are subject to future revisions as the state of the art and experience dictate." *Id.*

In 1991, TWGDAM released revised versions of the guidelines noting that “[t]he revised [quality assurance] guidelines * * * build on the foundation established by the original TWGDAM guidelines and address the technical issues related to the next generation of DNA typing methods based on the Polymerase Chain Reaction (PCR).” *Id.* at 47. The guidelines were again revised in 1995 based on proposed changes submitted to and voted on by TWGDAM at a January 1995 meeting. TWGDAM continues to exist today, though its name has changed to Scientific Working Group on DNA Analysis Methods (SWGDM).

In 1994, Congress passed the DNA Identification Act of 1994. Pub. L. No. 103-322, §§ 210301-06, 108 Stat. 1796, 2065-71 (1994). The Act gave the Director of the FBI the authority to create national guidelines for crime laboratories in the United States that conducted DNA testing and to appoint a DNA Advisory Board to develop and recommend quality assurance standards to the Director. *Id.* at § 201303(a)(1)-(3), 108 Stat. at 2068 (codified at 42 U.S.C. § 14131(a)(1)-(3)). The Act provided that DAB was to exist for five years but gave the Director the authority to extend the duration of the board if necessary. *Id.* at § 201303(b)(4), 108 Stat. at 2069 (codified at 42 U.S.C. § 14131(b)(4)). Last, the Act provided that the TWGDAM guidelines would serve as the standards until the Director approved the DAB standards. *Id.* at § 201303(a)(4), 108 Stat. at 2069 (codified at 42 U.S.C. § 14131(a)(4)).

DAB began meeting in 1995 and met two or three times a year for five years. One of the members of DAB, Dr. Budowle, the senior scientist in the laboratory division of the FBI, was also the chair of TWGDAM. When called as a witness in this case, Dr. Budowle testified that TWGDAM became the working arm of DAB in that during the time that DAB was in existence, TWGDAM continued to meet and develop recommended quality assurance standards for DAB. These recommended standards were then submitted to DAB, which in turn submitted its

recommendations to the Director. A letter to all CODIS laboratory managers stated that the Director approved the standards recommended by DAB on July 15, 1998, and that they were effective October 1, 1998. Dr. Budowle testified that all crime laboratories performing DNA testing that were involved in CODIS or subject to federal standards were required to comply with these DAB standards.

The DAB standards provided that as long as DAB was in existence, it could continue to recommend revisions to the standards to the Director. After DAB ceased to exist, the DAB standards permitted TWGDAM to recommend standard revisions to the Director as necessary. Dr. Arthur Eisenberg, the chairman of DAB for two years and a member of TWGDAM, testified that the TWGDAM guidelines were replaced by the DAB standards and he believed compliance with the DAB standards was essential to demonstrate that the work performed on DNA testing was reliable. Gross, the BCA representative to TWGDAM, also stated in her affidavit that the DAB standards superseded the TWGDAM guidelines and were adopted by the BCA in October 1998 as the appropriate standards and procedures with which the BCA must comply.

In determining whether the DAB standards or the TWGDAM guidelines should apply in this case, the court of appeals concluded that the district court erred in finding that the DAB standards superseded the TWGDAM guidelines. *Traylor*, 641 N.W.2d at 340-41. In looking at this court's prior cases, the court of appeals concluded that we have clearly and unequivocally adopted the TWGDAM guidelines and guarantees of reliability contained therein. *Id.* In the opinion of the court of appeals, these guarantees are absent from the DAB standards, and thus, the TWGDAM guidelines remain the standard for determining the reliability of DNA evidence. *Id.* at 341.[\[7\]](#)

The court of appeals was partially correct in that in the past we have looked to the TWGDAM guidelines for guidance in determining what standards and procedures a laboratory should implement to ensure reliable results. *See, e.g., State v. Schneider*, 597 N.W.2d 889, 894 (Minn. 1999); *State v. Johnson*, 498 N.W.2d 10, 14 (Minn. 1993); *Jobe*, 486 N.W.2d at 419; *Schwartz*, 447 N.W.2d at 427-28. But while we have looked to the TWGDAM guidelines as the measure against which laboratory protocols could be evaluated, we have never adopted the TWGDAM guidelines as an absolute. In *Schwartz*, we held that “the admissibility of specific test results in a particular case hinges on the laboratory’s *compliance with appropriate standards and controls*,” not a particular set of guidelines. 447 N.W.2d at 428 (emphasis added). Likewise, in *Jobe*, we noted that “[t]his court has recognized [the TWGDAM] guidelines *as appropriate for guiding DNA testing*.” 486 N.W.2d at 419 (emphasis added). We have not held, however, that the standards and procedures laid out in the TWGDAM guidelines were the only standards and guidelines acceptable for forensic laboratories doing DNA testing. Instead, we look to the standards and procedures that are currently accepted by the scientific community for guidance in determining what is necessary to ensure reliable results in DNA testing.

Like the court of appeals, Traylor’s focus also centers on the TWGDAM guidelines. However, his focus is more on the quality and reliability assurance aspects of the TWGDAM guidelines rather than strict adherence to the rules. Traylor argues that *Schwartz* endorsed the TWGDAM guidelines because they contained the requirement of open access to all work product and data needed to ensure the reliability of a particular DNA test and that the DAB standards are lacking such requirements.^[8] Because the DAB standards do not require as much disclosure of information, Traylor contends that compliance with the DAB standards is not sufficient to ensure reliable results. ^[9]

While recognizing that the DAB standards do not necessarily contain all the disclosure requirements of the TWGDAM guidelines, we also recognize that the standards and procedures must evolve over time as the technology and the knowledge of the experts change. In this case, the extensive disclosure that was originally required may no longer be necessary as the scientific community gains more understanding and familiarity with PCR-STR technology and the kits. We look to the scientific community and the standards and controls that it has adopted to determine what must be disclosed in order to validate a particular DNA testing process or methodology, recognizing that constitutional concerns may prevent the admissibility of the evidence.

The record clearly demonstrates that TWGDAM was actively involved in developing the DAB standards and procedures that are now being followed by crime laboratories across the country to ensure reliable results. Further, testimony of the experts involved in the development and implementation of the DAB standards provides additional support that the DAB standards have replaced the TWGDAM guidelines in the scientific community as the applicable quality assurance standards. Accordingly, we hold that the district court did not abuse its discretion in finding that the TWGDAM guidelines have been superseded by the DAB standards and that the DAB standards are the appropriate standards and procedures against which laboratories must be measured to ensure the foundational reliability of DNA testing.

Having decided that the DAB standards and procedures govern, we turn then to the second issue raised concerning foundational reliability: did the district court abuse its discretion in concluding that the BCA complied with the DAB standards? To show the BCA's compliance with DAB standards, the state presented an affidavit from Gross, a forensic scientist responsible for DNA testing at the BCA. Gross' affidavit documented the BCA's quality control and

assurance program, the validation studies performed, and the BCA's compliance with the DAB standards. In her affidavit, Gross stated that the BCA's quality control/quality assurance program consists of five parts:

- (a) Standard operating procedures [that] have been tested and validated.
- (b) Controls built into the testing that allow the testing to be monitored throughout each of the PCR typing steps. These include reagent blanks, blind controls, positive amplification and negative amplification controls.
- (c) Open proficiency testing of all personnel involved in casework.
- (d) Verification of case results by a second trained DNA scientist.
- (e) Review of case results by the [Quality Assurance/Quality Control] Supervisor of the Biology Section * * *.

Gross' affidavit also described the ten validation studies performed by the BCA prior to using the PCR-STR and kits for actual casework. Those studies include: (1) a comparison of samples previously run on a 377 DNA Sequencer to samples run on a 310 Genetic Analyzer to verify that results from both machines are comparable,[\[10\]](#) (2) an evaluation of the length of time a capillary could be used and still achieve quality resolution of the DNA fragments, (3) assessment of mixtures to establish a baseline for the interpretation of mixture results, (4) an evaluation of the smallest amount of DNA required to obtain a STR profile and the consequences of going below that amount, (5) re-analysis of results previously obtained using prior testing methodologies, and (6) an evaluation of how STR analysis will be affected when DNA samples are subjected to environmental insults and contaminants.

Traylor does not take issue with the state's contention that the BCA complies with the DAB standards. Therefore, given Gross' detailed affidavit documenting BCA's compliance with the DAB standards, the district court had sufficient evidence to conclude that the BCA complied with the DAB standards. Accordingly, we hold that the district court did not abuse its discretion in this regard.

Separate from his *Frye-Mack* challenge to the admission of the DNA evidence, Traylor also asks that we address whether due process concerns prevent the admission of the DNA evidence. Traylor relies heavily on *State v. Schwartz* in making this constitutional challenge. 447 N.W.2d at 427-28. In *Schwartz*, we recognized that “[t]he fair trial and due process rights [under the Constitution] are implicated when data relied upon by a laboratory in performing tests are not available to the opposing party for review and cross examination.” 447 N.W.2d at 427. We further noted in *Schwartz* that “[i]deally, a defendant should be provided with the actual DNA sample(s) in order to reproduce the tests” and that if that is not possible, “access to the data, methodology, and actual results is crucial so a defendant has at least an opportunity for independent expert review.” *Id.* Our Minnesota discovery rules also echo the concerns set forth in *Schwartz*. Rule 9.01, subd. 1(4) of the Minnesota Rules of Criminal Procedure provides that defense counsel has a right to inspect results of scientific tests and that, if a test precludes any further testing, the defense must receive reasonable notice and an opportunity to have a qualified expert observe the test.

The state contends that the BCA’s policy fully addresses the access to information concerns stated in *Schwartz* and in the discovery rules. Specifically, the state points to the BCA’s policy, which requires that, when possible, a portion of the evidence sample be retained at the BCA laboratory. If the entire sample must be used, the BCA’s policy requires the scientist to notify the prosecuting attorney so that the defense has the opportunity to have its own expert observe the testing. In this case, as is common in PCR-STR testing situations, the DNA sample was not consumed, and a portion of the DNA sample was available for further testing by Traylor. Further, the state contends that Traylor had full access to all information in the BCA’s possession. Such available information included extensive documentation of the BCA’s work,

including methodology, actual results of all testing, and compliance with standards and controls. Therefore, the state asserts, the BCA has provided Traylor with sufficient access to the laboratory's testing data and results for review and cross-examination, allaying constitutional concerns.

Traylor contends, however, that there is not sufficient information available because the issue is the reliability of the methodology employed by Perkins-Elmer, not the BCA. Traylor argues that "allowing the defense to observe while a BCA technician employs unknown chemicals will obviously not permit the defense to testify about the deficiencies in these chemicals." In Traylor's view, the lack of known primer sequences and the details of Perkins-Elmer's validation studies violates his due process right to a fair trial and necessitates the suppression of the DNA evidence.

We are not persuaded by Traylor's argument. In *Schwartz*, the court looked at the disclosure made by a commercial laboratory that performed the DNA testing using the RFLP method. *Schwartz*, 447 N.W.2d at 427. In that case, the laboratory disclosed to the defense its "DNA Fingerprinting" protocol, laboratory notes from the testing, the autoradiographs produced during RFLP analysis and statistical frequency tables. *Id.* The defense then requested more specific information about the commercial laboratory's methodology and population data base and was refused. *Id.* While we held in *Schwartz* that the DNA evidence was not admissible because the commercial laboratory did not publish sufficient information about its methodology and probes, our holding was rooted in our recognition that the applicable standards and controls in effect at that time required such disclosure. *Id.* at 427-28. In this case, the TWGDAM standards applicable in *Schwartz* have been superseded by the DAB standards. That fact alone does not fully address the constitutional concern raised by Traylor here, but it allows us to

understand the principle set forth in *Schwartz*. While the court in *Schwartz* did suppress the evidence, it also recognized that trade secrets and proprietary information may necessitate protective orders and, by implication, even denial of discovery: “Arguably, trade secrets may be at stake for the commercial laboratories. Protective measures could be pursued, however, before denial of discovery is appropriate.” *Id.* at 427.

In the instant case, Traylor is seeking information on Perkins-Elmer’s primer sequences and validation studies. Perkins-Elmer contends that the primer sequences are trade secrets and originally refused to release both its validation studies and the primer sequences.^[11] As noted in *Schwartz*, because of the proprietary nature of this information, a protective order should first be pursued in such cases. *Id.* Traylor did have a subpoena issued to Perkins-Elmer, and Dr. William Shields, an expert for Traylor, was allowed to view copies of Perkins-Elmer’s validation studies under a protective order. Even having received the validation studies under protective order, Traylor contends that the validation studies were worthless because Dr. Shields was not allowed to testify about the studies’ deficiencies and was not given the underlying data. The district court rejected Traylor’s constitutional challenge, concluding instead that the BCA’s validation studies were sufficient to validate the admissibility of the DNA evidence and that the disclosure of the primer sequences as well as unlimited access to Perkins-Elmer’s validation studies was not necessary.

We agree with the district court. Due process requires that the defense have the same amount of information as the prosecution on a scientific test so that the defense is able to adequately cross-examine the prosecution’s experts. In this case, the BCA did not have Perkins-Elmer’s validation studies or the primer sequences when it performed DNA analysis using the kits. Instead, through the use of its own testing of the kits, the BCA validated that the kits

produce reliable results. Traylor likewise could have obtained the kits and performed the same type of validation testing as the BCA laboratory. Moreover, Traylor could have perused any number of publicly available validation studies that have been performed on these kits since their inception.[\[12\]](#) With the DAB standards and procedures to guide him, Traylor could have also questioned the BCA technicians about the procedures and methodology followed, their validation studies, and their interpretation of the results. Traylor did not need the primer sequences or unlimited access to Perkins-Elmer's validation studies to do so. Finally, and importantly, there was a portion of the DNA sample at issue available for Traylor to perform his own tests, an opportunity Traylor did not pursue. Accordingly, we conclude that the district court did not abuse its discretion in ruling that Traylor's due process right to a fair trial was not violated.

In summary, we hold that there is sufficient evidence to conclude that PCR-STR DNA testing is generally accepted in the relevant scientific community as required under the first prong of the *Frye-Mack* test. Recognizing that the appropriate standards and controls required to ensure reliability under the second prong of the *Frye-Mack* test may change as DNA technology and testing evolves, we hold that the district court did not abuse its discretion in concluding that the appropriate standards and controls currently in effect are the DAB standards and that the BCA complied with those standards. Finally, we hold that disclosure of the primer sequences and unlimited access to Perkins-Elmer's validation studies are not necessary for the scientific community to validate the Profiler Plus and Cofiler kits and, therefore, that Traylor's due process right to a fair trial has not been violated. Accordingly, while we reverse the court of appeals' conclusion that the district court erred in applying the DAB standards instead of the TWGDAM guidelines, we affirm the court of appeals decision upholding Traylor's conviction.

Affirmed.

[1] “Degraded” DNA refers to DNA that has begun to break down.

[2] Fed. R. Evid. 702 reads as follows:

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, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.

[3] Available on the web at www.cstl.nist.gov/biotech/strbase/str_ref.htm. The database, most recently updated on January 13, 2003, contains bibliographical information for 1751 articles, of which 974 are peer-reviewed.

[4] K.M. Sullivan, et al., *Automated DNA Profiling by Fluorescent Labeling Of PCR Products*, 2 PCR Meth. Appl. 34 (1992); L. Roewer and J.T. Eppelen, *Rapid and Sensitive Typing of Forensic Stains by PCR Amplification of Polymorphic Simple Repeat Sequences In Case Work*, 53 Forensic Sci. Int. 163 (1992). Notably, a number of other state courts have also found PCR technology to be both widespread and reliable. *See, e.g., Ex Parte Taylor*, 825 So.2d 769, 778 (Ala. 2002) (holding that the Perkins-Elmer kit was reliable); *State v. Belken*, 633 N.W.2d 786, 798 (Iowa 2001) (holding that PCR method has emerged as predominant method of DNA typing and is accepted in both forensic and non-forensic settings); *Commonwealth v. McNickles*, 753 N.E.2d 131, 139-40 (Mass. 2001) (noting that PCR testing has previously been upheld by the

court); *State v. Pappas*, 776 A.2d 1091, 1108 (Conn. 2001) (holding that PCR amplification is generally accepted and scientifically valid).

[5] The National Institute of Standards and Technology lists several hundred articles dealing with STRs. Among those articles listed are the following: H.A. Hammond, et. al., *Evaluation of 13 Short Tandem Repeat Loci for Use in Personal Identification Application*, 55 *Am. J. Human Genetics* 175 (1994); A. Edwards, *Strategy for Identification and Isolation of Short Tandem Repeats*, Proceedings from the 2nd International Symposium on Human Identification 309 (1991); C.T. Caskey and H.A. Hammond, *Forensic Use of Short Tandem Repeats Via PCR*, 4 *Advances in Forensic Haemogenetics* 18 (1992); C.J. Fregeau, and R.M. Fourney, *DNA Typing with Fluorescently Tagged Short Tandem Repeats: A Sensitive and Accurate Approach to Human Identification*, 15 *BioTechniques* 100 (1993).

[6] The National Institute of Standards and Technology includes bibliographical information on the following articles, among others: R.L. Alford, et al., *Rapid and Efficient Resolution of Parentage By Amplification of Short Tandem Repeats* 55 *Am. J. Human Genetics* 190 (1994); J.P. Whitaker, et al., *Short Tandem Repeat Typing of Bodies From a Mass Disaster: High Success Rate and Characteristic Amplification Patterns in Highly Degraded Samples*, 18 *BioTechniques* 670 (1995); T.M. Clayton, et al., *Identification of Bodies From the Scene of a Mass Disaster Using DNA Amplification of Short Tandem Repeat (STR) Loci*, 76 *Forensic Sci. Int.* 7 (1995); Roy, R., et al., *Producing STR Locus Patterns from Bloodstains and Other Forensic Samples Using an Infrared Fluorescent Automated DNA Sequencer*. 41 *J. Forensic Sci.* 418 (1996); P. Gill et. al., *Criminal Intelligence Databases and Interpretation Of STRs*. 6 *Advances in Forensic Haemogenetics* 235 (1996); J.A. Thomson, et al., *Analysis of STR Loci in Old Blood Stains Using Automated and Manual Genotyping Systems*, 6 *Advances in Forensic*

Haemogenetics. 328 (1996); W.M. Schmerer, *Optimized DNA Extraction to Improve Reproducibility of Short Tandem Repeat Genotyping with Highly Degraded DNA as Target*, 20 Electrophoresis 1712 (1999).

[7] The court of appeals also stated that this court has reaffirmed the need for compliance with the TWGDAM guidelines after the DAB standards were adopted in October 1998 in *State v. Schneider*, 597 N.W. 2d 889 (Minn. 1999). *Traylor*, 641 N.W.2d at 340. However, while the *Schneider* case was not decided by this court until 1999, the actual DNA testing was done in 1997, before the DAB standards were adopted. *Schneider*, 597 N.W.2d at 891.

[8] Specifically, *Traylor* takes issue with the fact that the DAB standards no longer require that the PCR primer be of known sequence or be made readily available to the scientific community. *Traylor* also takes issue with Perkins-Elmer's failure to disclose their validation studies, noting that the TWGDAM guidelines require that "the results of developmental validation studies be shared as soon as possible with the scientific community through presentations at scientific/professional meetings" and that "details of [the] studies be available for peer review through timely publications in scientific journals." Technical Working Group on DNA Analysis Methods, *Guidelines for a Quality Assurance Program for DNA Analysis, Section 4.1.5.12*, 22 Crime Laboratory Digest, No. 2, 21, 26 (1995). In contrast, the DAB standards, while requiring developmental validation studies be done, do not explicitly require publication and peer review of such studies.

[9] *Traylor* contends that the reason that the requirement of full disclosure of the primer sequences was not included in the DAB standards was because the FBI knew that a private laboratory would never undertake to develop the kits without some guarantees that its trade secrets would be protected. Therefore, *Traylor* asserts the change in procedure was not done to

protect the reliability of the test, but to bring the guidelines into compliance with current practice. While Traylor suggests that the scientific community compromised its standards to encourage the manufacturer's development of a needed product, we have previously recognized the importance of a company's trade secrets in *Schwartz*, when we stated that "[a]rguably, trade secrets may be at stake for the commercial laboratories" and "[p]rotective measures could be pursued * * * before denial of discovery is appropriate." 447 N.W.2d at 427. Our statements in *Schwartz* seem to imply that discovery may be completely thwarted if a protective order is not sufficient and a trade secret is a viable reason for refusing to disclose certain information.

[10] These two machines use different methods of separating the DNA fragments: the 377 DNA Sequencer uses a slab gel, and the 310 Genetic Analyzer employs a capillary.

[11] Subsequent to the court of appeals decision, Perkins-Elmer published their validation studies.

[12] See, e.g., J.F. Anderson et al., *Further Validation of a Multiplex STR System for Use in Routine Forensic Identity Testing*, 78 *Forensic Sci. Int.* 47 (1996); R.R.E. Frazier et al., *Validation of the Applied Biosystems PrismTM 377 Automated Sequencer for Forensic Short Tandem Repeat Analysis*, 17 *Electrophoresis* 1550 (1996); J.E. Lygo et al., *The Validation of Short Tandem Repeat (STR) Loci for Use in Forensic Casework*, 107 *Int. J. Leg. Med.* 77 (1994).

Also available on the web at <http://www.cstl.nist.gov/biotech/strbase/valid.htm> is a reference listing of additional validation studies.