STATE OF CONNECTICUT *v.* STEPHEN PAPPAS (SC 16257)

McDonald, C. J., and Borden, Norcott, Katz and Palmer, Js.*

Argued November 1, 2000—officially released July 24, 2001

Counsel

Darcy McGraw, special public defender, for the appellant (defendant).

Robert J. Scheinblum, assistant state's attorney, with whom were *Paul E. Murray*, supervisory assistant state's attorney, and, on the brief, *Kevin T. Kane*, state's attorney, for the appellee (state).

Opinion

MCDONALD, C. J. After a jury trial, the defendant, Stephen Pappas, was convicted of robbery in the third degree in violation of General Statutes § 53a-136 (a),[1] and larceny in the second degree in violation of General Statutes § 53a-123 (a) (2).[2] The defendant, who also had been charged with being a persistent felony offender, entered a plea of guilty to that charge. The trial court rendered judgment in accordance with the verdict and the plea, and the defendant appealed to the Appellate Court. Thereafter, we transferred the appeal to this

court pursuant to General Statutes § 51-199 (c) and Practice Book § 65-1.

On appeal, the defendant claims that the trial court improperly: (1) denied his motion to suppress certain evidence; (2) denied his motion in limine to exclude mitochondrial deoxyribonucleic acid (mtDNA) evidence under *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 113 S. Ct. 2786, 125 L. Ed. 2d 469 (1993), adopted by this court in *State* v. *Porter*, 241 Conn. 57, 68, 698 A.2d 739 (1997), cert. denied, 523 U.S. 1058, 118 S. Ct. 1384, 140 L. Ed. 2d 645 (1998); (3) concluded that the probative value of that mtDNA evidence was not outweighed by undue prejudice; and (4) admitted certain hearsay evidence. We disagree with the defendant and, therefore, affirm the judgment of the trial court.

On October 7, 1994, at approximately 9:56 a.m., a male wearing a navy blue hooded sweatshirt, baggy navy blue pants, and turquoise gloves entered a branch of Citizens Bank on Ocean Avenue in New London and stated, ''This is a robbery.'' The robber wore the hood of the sweatshirt over his head, and his face was covered by a piece of cloth attached to the hood. He climbed over the teller counter, removed approximately $5530 in cash from the teller drawers, and stuffed the money into his pants and sweatshirt. Some of that money was ''bait money''—specially wrapped packages of $10 bills, the serial numbers of which had been recorded by the bank. The robber then climbed back over the teller counter, exited through the front door, walked across the bank's parking lot by a gas station and fled in the direction of railroad tracks that ran beneath Ocean Avenue. Once the robber had fled, the branch manager locked the doors of the bank and called the Federal Bureau of Investigation (FBI).

There were four employees and two customers present in the bank at the time of the robbery. They testified at trial that they knew that the robber was male by the sound of his voice and that he appeared to be wearing more than one layer of clothing. One of the customers, Linda Schwartz, testified that she saw the robber's face when he lifted the cloth that was covering his face so that he could see. Schwartz told the FBI that the robber had a prominent nose, a very sallow complexion and a few scars or shaving nicks. Approximately two weeks after the robbery, Schwartz identified the defendant as the robber from a photographic array shown to her by the FBI. She repeated her identification at the trial.

Soon after the robbery, Officers Marshall Segar and Eric Deltgen and Detective Gerard Gaynor of the New London police department converged upon the area surrounding the robber's path of flight. Segar stopped at the Ocean Avenue overpass, looked westbound along the railroad tracks toward the New London-Waterford town line, and observed a man fitting the robber's

description running west along the railroad tracks. The suspect appeared to be wearing multiple layers of clothing and was holding his midsection. Segar and Deltgen tried to intercept the suspect but were unsuccessful. Deltgen then spoke with several witnesses at the gas station located next to the bank's parking lot, and he traced the suspect's path of flight through an opening in a fence and down an embankment to the railroad tracks. He observed a pair of "tan to teal-colored" gloves in the middle of the railroad tracks slightly west of the Ocean Avenue overpass. Approximately ten feet west of the gloves, he observed cash, some of which was bundled, and the rest of which was scattered along the railroad tracks over a distance of approximately 200 feet. Shortly thereafter, Gaynor arrived and took custody of the gloves and money. The police recovered a total of $2231 that had been stolen during the robbery.

Approximately thirty minutes after the robbery, Officer Gregory Williams arrived in an all terrain vehicle and searched a one mile stretch of densely wooded wetlands surrounding the railroad tracks from Ocean Avenue in New London west to Miner Lane in Waterford. During his search, he discovered a blue hooded sweatshirt on the ground at the base of the railroad tracks.

The defendant was charged with, and ultimately convicted of, robbing the bank. Additional facts will be set forth as required.

I

The defendant first claims that the trial court improperly denied his motion to suppress hairs that were obtained from his head pursuant to a search warrant. The defendant argues that the affidavit accompanying the warrant application contained false statements and that the trial court improperly denied his request for an evidentiary hearing under *Franks* v. *Delaware*, 438 U.S. 154, 98 S. Ct. 2674, 57 L. Ed. 2d 667 (1978). We disagree.

The following facts are necessary to resolve this claim. In February, 1996, after the defendant had been identified as a potential suspect, the FBI requested that Detective David Gigliotti obtain samples of the defendant's head hair so that they could be compared with two hairs that had been found by the FBI on the sweatshirt. On February 5, 1996, Gigliotti obtained a search warrant that authorized the seizure of a sample of the defendant's head hair. Pursuant to the search warrant, Gigliotti obtained samples of the defendant's hair by pulling them from the defendant's head, and he submitted the samples to the FBI laboratory for analysis. These samples, however, were rejected by the FBI laboratory because they had been pulled, rather than combed, from the defendant. The FBI requested that Gigliotti obtain new samples from the defendant by

combing the hairs from the defendant's head. On September 23, 1996, Gigliotti obtained a second search warrant and obtained hair samples from the defendant by combing his hair. Gigliotti sent those samples to the FBI laboratory, which analyzed them, and the analytical evidence subsequently was introduced during the defendant's trial.

The defendant filed a motion to suppress the hair samples and information obtained from those samples on the ground that the search warrant lacked probable cause. The defendant argued that the warrant affidavit contained misstatements that had been made either knowingly and intentionally, or with reckless disregard for the truth, and therefore that a hearing was required pursuant to *Franks* v. *Delaware*, supra, 438 U.S. 171–72. The defendant further argued that, if the allegedly false statements were set aside, the affidavit's remaining content was insufficient to establish probable cause. The trial court, after a hearing on the defendant's motion to suppress, denied his motion.

Because the head hairs that had been obtained under the first warrant were not introduced as evidence at the defendant's trial, we confine our review to the affidavit accompanying the second warrant application.[3] The defendant argues that two statements in the affidavit were intentionally false. The defendant contends that: (1) by stating that ''[t]he subsequent police search of the railroad tracks led to the discovery of a pair of gloves, a sweatshirt, and in excess of two thousand dollars in currency,'' the affiants falsely implied that the sweatshirt was found with the gloves and money, when in fact the sweatshirt was found in a different location along the railroad tracks; and (2) by stating that ''[t]he gloves and sweatshirt were identified by bank tellers involved as appearing similar to those worn by the suspect,'' the affiants falsely stated that the police had shown the sweatshirt to the bank tellers following the robbery. At the hearing on the motion to suppress, the state conceded that the police had not shown the sweatshirt to the bank tellers who had witnessed the robbery and, therefore, that the latter statement should not be considered by the court in assessing whether the warrant established probable cause to seize hairs from the defendant.

''In order for a defendant to challenge the truthfulness of an affidavit underlying a warrant at a *Franks* hearing, he must: (1) make a substantial preliminary showing that a false statement knowingly and intentionally, or with reckless disregard for the truth, was included by the affiant in the warrant affidavit; and (2) show that the allegedly false statement is necessary to a finding of probable cause. . . . If the allegedly false statement is set aside, however, and there remains sufficient evidence to establish probable cause, a *Franks* hearing is not necessary.'' (Citation omitted; internal quotation

marks omitted.) *State* v. *Bergin*, 214 Conn. 657, 666, 574 A.2d 164 (1990).

In the present case, we need not decide whether the defendant made a substantial showing that the affiants' statements were intentionally false or that they had been made with reckless disregard for the truth. We agree with the trial court's conclusion that, even without the identification of the sweatshirt and gloves, and the location of the sweatshirt with the gloves and the stolen money, the affidavit was sufficient to establish probable cause to seize hairs from the defendant, and therefore a *Franks* hearing was not necessary. See id.

"Whether the trial court properly found that the facts submitted were enough to support a finding of probable cause is a question of law. . . . The trial court's determination on [that] issue, therefore, is subject to plenary review on appeal." (Citation omitted.) *State* v. *Clark*, 255 Conn. 268, 279, 764 A.2d 1251 (2001). "Probable cause to search exists if: (1) there is probable cause to believe that the particular items sought to be seized are connected with criminal activity or will assist in a particular apprehension or conviction . . . and (2) there is probable cause to believe that the items sought to be seized will be found in the place to be searched." (Internal quotation marks omitted.) *State* v. *Vincent*, 229 Conn. 164, 171, 640 A.2d 94 (1994). "Probable cause, broadly defined, [comprises] such facts as would reasonably persuade an impartial and reasonable mind not merely to suspect or conjecture, but to believe that criminal activity has occurred. . . . Reasonable minds may disagree as to whether a particular affidavit establishes probable cause." (Citations omitted; internal quotation marks omitted.) *State* v. *Diaz*, 226 Conn. 514, 541, 628 A.2d 567 (1993).

"In determining the existence of probable cause to search, the magistrate should make a practical, commonsense decision whether, given all of the circumstances set forth in the affidavit . . . there is a fair probability that contraband or evidence of a crime will be found in a particular place. . . . In making this determination [of probable cause], the magistrate is entitled to draw reasonable inferences from the facts presented. When a magistrate has determined that the warrant affidavit presents sufficient objective indicia of reliability to justify a search and has issued a warrant, a court reviewing that warrant at a subsequent suppression hearing should defer to the reasonable inferences drawn by the magistrate." (Citations omitted; internal quotation marks omitted.) *State* v. *Cobb*, 251 Conn. 285, 317, 743 A.2d 1 (1999), cert. denied, U.S. , 121 S. Ct. 106, 148 L. Ed. 2d 64 (2000).

The warrant affidavit alleged that: all of the witnesses to the robbery had told the police that the robber had worn a blue or gray hooded sweatshirt and had appeared to be wearing multiple layers of clothing;

within one hour of the robbery the police had found the sweatshirt and some of the stolen bank money near the suspect's path of flight along railroad tracks; the FBI had removed two human hairs from the sweatshirt; the defendant was the same approximate age, height and build as witnesses had described the bank robber; one of the witnesses had viewed a photographic array that included a photograph of the defendant, and that witness positively identified the photograph of the defendant as the man who had committed the robbery; acquaintances of the defendant had stated that the defendant had visited the same day as the robbery and showed ''a lot'' of money that was stuffed in his pants, appeared to be ''real nervous,'' and was wearing multiple layers of clothing that appeared to be ''soaked''; the robber would have appeared wet or soaked had he hidden in the marshy area around the suspect's path of flight; and the defendant previously was planning to rob a bank.

We conclude that, even without the statements that witnesses of the robbery had been shown the sweatshirt and gloves for identification and that the sweatshirt had been discovered with the gloves and stolen cash, the warrant affidavit established probable cause to believe that hairs from the defendant's head would assist in the apprehension or conviction of the suspect who had committed the robbery. We note that, although the gloves and sweatshirt were not found in the same place along the railroad tracks, both were located, as was the stolen money, in the rail corridor through which the suspect had fled. Accordingly, we conclude that the trial court properly denied the defendant's request for a *Franks* hearing and his motion to suppress the hair evidence.

II

The defendant next claims that the trial court improperly denied his motion in limine to exclude mtDNA evidence under the standard set forth in *State* v. *Porter*, supra, 241 Conn. 62, 66–68. We disagree.

The following additional facts are relevant to this claim. During their investigation, the police recovered two head hairs from the sweatshirt (questioned sample) that had been recovered following the robbery. The FBI performed an mtDNA analysis of the questioned sample and the defendant's head hair (known sample), compared the results and concluded that the defendant could not be excluded as the source of the questioned sample.

Before trial, the defendant moved to exclude all evidence regarding mtDNA testing and analysis and, pursuant to *State* v. *Porter*, supra, 241 Conn. 57, requested a hearing as to the reliability of mtDNA testing and analysis. During the hearing, the trial court heard testimony from the state's expert, FBI Special Agent Mark Wilson,

and the defendant's expert, William Shields, a professor of biology.

After setting forth his qualifications, Wilson testified about DNA generally, the mtDNA extraction process and the statistical significance of a match of mtDNA types. Wilson explained that DNA is the genetic material found in the cells of all living organisms that is passed on to each succeeding generation. DNA is a complex molecule that forms a double helix structure, which resembles a twisted ladder or a circular staircase. The railing of the staircase is the ''backbone'' of the DNA molecule, and the ''steps'' consist of chemicals called nucleotides or bases. There are four chemical bases in DNA: guanine (G); cytosine (C); adenine (A); and thymine (T). These bases pair up with each other in a specific order to form base pairs, i.e., G always pairs with C, and A always pairs with T. The particular sequence in which the base pairs are arranged along the backbone of the DNA molecule and the length of the molecule itself are the features used in forensic DNA analysis.

Wilson testified that DNA is located in two places in humans. The vast majority of DNA is stored within the nucleus of a human cell and is known as nuclear DNA. Nuclear DNA consists of approximately three billion base pairs, and the particular sequence of the base pairs in nuclear DNA makes each individual unique and accounts for our genetic traits.

Wilson explained that mitochondrial DNA, or mtDNA, differs from nuclear DNA with respect to its location within a cell, its uniqueness among individuals, sequence length and its mode of inheritance. First, mtDNA is found within mitochondria, which are circular structures surrounding the cellular nucleus that provide a cell with energy. Second, mtDNA, unlike nuclear DNA, cannot be used to establish positive identification because mtDNA consists of but a single ''marker'' that is approximately 16,569 base pairs in length. By comparison, nuclear DNA consists of approximately three billion base pairs and many discrete markers, or loci, that may be compared to establish a positive match between DNA samples. Wilson explained that, because mtDNA has only one marker, the probability of a random match is much higher between mtDNA samples than between nuclear DNA samples. Thus, according to Wilson, mtDNA is significantly less probative of identity than is nuclear DNA. Third, whereas nuclear DNA is inherited from both parents, mtDNA is inherited maternally.

Wilson testified that scientists analyze mtDNA, like nuclear DNA, according to its sequence. He explained that the information in an mtDNA sequence is analogous to a telephone number; the seven digits in a given telephone number are arranged in a particular order. Similarly, the order in which the A-T and G-C base pairs are arranged along the DNA staircase can distinguish

one sample from another. Wilson further explained that the mtDNA molecule consists of two areas: the coding region, which regulates the reproduction of various biological molecules; and the control region, which regulates the mtDNA molecule itself. Research has shown that two regions of mtDNA within the control region exhibit the greatest variation between unrelated persons. These regions, Hypervariable Region I (HV1) and Hypervariable Region II (HV2), each consists of approximately 300 base pairs. MtDNA analysis is based upon the sequence in which the nucleotides, or chemical bases, are ordered in the 610 base pairs within HV1 and HV2.

Wilson also explained the FBI's process of analyzing hair for evidence of mtDNA. The trial court, in its oral decision, summarized that process as follows: ''[T]he first step in an mtDNA analysis of a hair sample is to perform microscopic analysis. If the hairs appear microscopically similar, then mtDNA analysis is performed to determine on a molecular level whether or not the hair is consistent with [hair] originating from a particular person.

''The next step is a washing step to remove any contaminating materials surrounding or coating the evidentiary sample. The next step is DNA extraction where the homogenate obtained by placing the hair sample in a solution and [while] grinding and shearing it is exposed to a mixture of organic chemicals which separate the DNA from other biological molecules such as proteins. The organic mixture is spun in a centrifuge, and the DNA is soluble in the top, water-based layer, while the rest of the cellular components are soluble in the bottom, organic layer or in the interface between the two [layers]. The top layer is then removed and filtered for further separation from the other cellular materials.

''The next step is amplification by Polymerase Chain Reaction (PCR). PCR is a technique which takes a small amount of DNA and copies it in a process known as amplification. The two strands of the DNA helix are separated from one another, which is accomplished by heating the sample. At this point, the original DNA molecules in the extract, called the templates, separate into their component strands. A new DNA strand is made by using an enzyme which copies the existing DNA molecule. This copying process is repeated a number of times and during each repetitive cycle the amount of DNA in the reaction is doubled. At the end of this process, many more copies of the original DNA in the extract are present.

''The next step is known as Post-Amplification Purification and Quantitation. This is to determine how much product was generated by PCR. This step is completed with a capillary electrophoresis machine. Blank samples, which contain no DNA, and known control sam-

ples are used in order to assess the amplification of the samples [to ensure that a sufficient number of copies have been made].

"The next step is sequencing. The method of DNA sequencing is known as Sanger's method. This technique uses the process of DNA synthesis to accomplish the determination of the sequence of bases in an individual's mtDNA. The sequencing process differs from PCR in that another set of the A, G, C, and T bases, with slight chemical differences, is added to the reaction mix. These bases differ from the normal bases in that they lack a chemical group that would normally allow the enzyme to place another base after them. These altered bases also carry a fluorescent dye which is readily detected by an automated machine. As they become incorporated into the growing DNA strand, the process of synthesis ends due to the inabilities of the enzyme to add another base to the altered fluorescent one. The sequencing reaction is subjected to thermal cycling, just as in PCR. The normal bases compete with the altered bases for incorporation into the new strand and what results is a collection of DNA products which, when pooled, have altered bases inserted at every possible position in the area to be sequenced.

"The next step is sequence determination. The many products resulting from the sequence reaction are separated based on their length through gel migration. The size of the pores in the gel matrix regulate the distance that each DNA product travels. These products all begin from the same starting point on a gel and the fluorescence detector from the sequencing machine reads off the bases as they occur from the bottom of the gel back up to the top. The identity of each being revealed by the fluorescent tag on the altered base. The machine will generate a chromatogram, or colored graph, depicting the wavelength of the dye that it reads one base at a time. The sequence of the DNA is determined from a series of these sequencing reactions."

Wilson also testified about the FBI procedures utilized to prevent and detect contamination of samples. He stated that mtDNA analysis is a sensitive process and that, because contamination could affect the result, the FBI laboratory procedures seek to eliminate contamination. He stated that the known and questioned samples are tested separately; the questioned sample is sequenced before the known sample is unsealed and processed. The lab areas, machines and pipettes used to process the DNA material are cleaned using a bleach solution or ultraviolet light. Wilson testified that the FBI lab uses several controls to monitor possible contamination: a reagent blank, a negative control, a positive control and a sequencing base control. The reagent blank is used throughout the process starting at the extraction step and it allows monitoring of the amount of DNA at each step of the process. The negative control

is introduced at the PCR step, and it would indicate contamination in the reagents. The positive control is a known DNA sequence that is introduced to ensure that the amplification reaction was successful and to assess the quality of the sequencing process. Wilson stated that contamination could reach 20 to 25 percent without compromising the typing results, but under the FBI protocol, if contamination exceeds 10 percent, then that sample is discarded and the process is performed again. Wilson testified that if contamination did occur, it would not cause a false positive (a false inclusion) but, rather, would result in a false negative (a false exclusion).

Finally, Wilson testified that the FBI laboratory undergoes semiannual external proficiency tests. The test provider sends samples to the FBI lab and the lab technicians analyze those samples as if they are evidence from a case. The test provider then compares the FBI lab results to the known sequences. Wilson testified that the FBI lab always has successfully completed these tests.

Wilson stated that extraction, PCR amplification, capillary electrophoresis, and the use of an automated sequencing machine to generate a chromatograph all are generally accepted within the scientific community. He stated that all of the techniques used in mtDNA analysis were developed for nonforensic uses, that he is not aware of any peer-reviewed articles that suggest that the FBI's mtDNA process or analysis are not scientifically valid, and that the results are objectively verifiable.

Wilson testified that, after the sequencing of the mtDNA, the next step compares the sequence in the questioned sample to the sequence in the known sample to determine whether they share a common base at every position along the 610 base pairs in HV1 and HV2. The FBI requires that two examiners independently examine the sequences in the case of sequence concordance; if both examiners conclude that the known and questioned samples share a common base at every position, then there is a match, which means that the questioned sample cannot be excluded as deriving from the same maternal lineage from which the donor's sample is derived. Wilson stated that the examiner cannot positively establish identity on the basis of mtDNA because all those having a common maternal lineage, absent mutation, share the same mtDNA.

Wilson also testified about heteroplasmy, which is the presence of two or more mtDNA sequences in an individual. He stated that heteroplasmy is observed in approximately 5 to 10 percent of cases, and that the presence of heteroplasmy would not lead to a false inclusion because, in order to match, the sequences would still have to share a common base at every position. Wilson testified that there was no evidence of

heteroplasmy in the present case.

The final step in mtDNA analysis compares the mtDNA sequence of the questioned sample to the FBI database of mtDNA sequences to determine the relative prevalence of that mtDNA sequence. At the time the defendant's hair was analyzed, the FBI database contained 1657 known sequences of mtDNA, 916 of which were Caucasian sequences. Using a statistical technique, the FBI estimates the rarity or prevalence of a given mtDNA sequence based upon whether the sequence has been observed in the database and, if so, how often it has been observed. Wilson explained that this method is not used to establish positive identification; rather, it allows the FBI to estimate, on the basis of its database, the probability that a given mtDNA profile would be expected to occur in the general population. He also stated that, although the most common mtDNA type probably has a population frequency of 4 percent, the database is not yet large enough to know the population frequency of rare types, that is, types that have not been seen in the database.

Wilson testified that the FBI had analyzed the mtDNA evidence prior to the defendant's trial. The FBI sequenced the mtDNA taken from the hair from the sweatshirt and from the defendant's hair, compared them and concluded that those samples shared a common base at every position. Thereafter, Wilson compared that sequence with those in the FBI database and found that the sequence previously had not been observed. Relying on that comparison, Wilson concluded that approximately 99.75 percent of the Caucasian[4] population could be excluded as the source of the mtDNA in the sample. Wilson stressed that this figure is based upon the database, so that as the database grows, the estimate would change.

After setting out his credentials, the defendant's expert, Shields, testified at the *Porter* hearing that the analysis and use of mtDNA as evidence of identity is problematic for three reasons. First, Shields stated that the FBI does not adequately address the potential for heteroplasmy—the presence of different sequences of mtDNA within one person. He stated that, until recently, most geneticists had assumed that an individual's mtDNA sequence would be identical within that individual and would be the same as the mtDNA sequence of that individual's mother. Shields testified that recent studies indicate that point heteroplasmy, a difference at one base pair in a sequence from samples of the same individual, occurs in between 10 to 20 percent of all people, and may occur in hair samples in 100 percent of the population. Shields testified that, because of the possibility of heteroplasmy, the FBI changed their matching criteria as to when two samples may be said to match, that is, when the donor of the known sample cannot be excluded as the source of the questioned

sample. Shields concluded that, while the new matching criteria reduce the probability of false negatives, they increase the likelihood of false positives, i.e., incorrectly including a known sample as a source of the questioned sample. Shields also testified that the FBI has not performed validation studies concerning the extent of contamination by the DNA of others resulting from their handling of mtDNA.

Shields stated that, even if it is assumed that heteroplasmy or contamination were not at issue, the statistical calculations used by Wilson are incorrect because of the way that the FBI determines a ''failure to exclude'' between two mtDNA samples. Shields stated that, because the FBI would not exclude as a match two samples that differed by one chemical base, other samples in the database that differ by one such base should be included in the estimated mtDNA type frequency. Shields concluded that, if one took into account samples in the FBI database that differed by one such base, the frequency of the mtDNA sequence observed from the defendant's sample in this case would be doubled. Thus, instead of a frequency of approximately 0.3 percent, which would mean that 99.7 percent of the Caucasian population could be excluded, Shields calculated that type frequency would be approximately 0.7 percent, which would exclude 99.3 percent[5] of the Caucasian population.

The trial court concluded that the mtDNA evidence was sufficiently reliable to be helpful to the jury in this case. The trial court found that the procedures used to analyze mtDNA (extraction, PCR amplification, and sequencing) are generally accepted in the community, that the FBI employed controls to minimize the risks of contamination, and that Wilson presented the methodology and data in a way that the court understood and that the jury would understand. The court also concluded that ''[i]ssues concerning the mtDNA process, such as contamination, inadequate controls, small size of the database, known error rate, false inclusions, no neutral peer review, heteroplasmy (meaning different sequences in a single individual), and prejudice in the way the conclusions are presented are claims that the jury should be made aware of.'' The court concluded that those issues go to the weight of the evidence and did not rise to a level that would undermine the admissibility of the mtDNA evidence. Accordingly, the trial court denied the defendant's motion to exclude the mtDNA evidence. We conclude that the trial court did not abuse its discretion in denying the defendant's motion to suppress the mtDNA evidence.

A

In *State* v. *Porter*, supra, 241 Conn. 68, we adopted the test for the admissibility of scientific evidence as set forth in *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.*, supra, 509 U.S. 592–93 (*Daubert* test). We stated:

''A trial judge should . . . deem scientific evidence inadmissible only when the methodology underlying such evidence is sufficiently invalid to render the evidence incapable of helping the fact finder determine a fact in dispute. . . . [A] sufficient showing of validity is necessary for scientific evidence to be helpful.'' *State* v. *Porter*, supra, 89.

Several factors properly may play a role in a court's assessment of the validity of a scientific methodology. ''[T]hese factors are not exclusive. Some will not be relevant in particular cases; and some cases will call for [other] considerations . . . .'' Id., 84. ''[C]ourts should . . . consider whether a scientific principle has gained general acceptance in making admissibility determinations.'' (Internal quotation marks omitted.) Id. ''Although general acceptance is no longer an absolute prerequisite to the admission of scientific evidence, it should, in fact, be an important factor in a trial judge's assessment. . . . That is, if a trial court determines that a scientific methodology has gained general acceptance, then the *Daubert* inquiry will generally end and the conclusions derived from that methodology will generally be admissible. If a principle has not gained general acceptance, however, we emphasize that a proponent of [the] scientific opinion . . . may [still] demonstrate the reliability or validity of the underlying scientific theory or process by some other means, that is, without establishing general acceptance.'' (Citations omitted; internal quotation marks omitted.) Id., 84–85.

The trial court, in determining whether a particular theory or technique is based on scientific knowledge, may also consider the following factors: (1) whether the theory or technique can be, and has been, tested; (2) whether it has been subjected to peer review and publication; and (3) the known or potential rate of error, including the existence and maintenance of standards controlling the technique's operation. Id., 64. Furthermore, in *Porter* we suggested that ''the prestige and background of the expert witness supporting the evidence can play a role in determining whether a novel technique employed by that individual is likely to have any scientific merit. . . . The extent to which the scientific technique in question relies on subjective interpretations and judgments by the testifying expert, rather than on objectively verifiable criteria, can also be a factor.'' (Citations omitted.) Id., 86. Courts may also consider ''whether a testifying expert can present and explain the data and methodology underlying his or her scientific testimony in such a manner that the fact finder can reasonably and realistically draw its own conclusions therefrom . . . [and] whether the scientific technique underlying the proffered expert testimony was developed and implemented solely to develop evidence for in-court use, or whether the technique has been developed or used for extrajudicial purposes.'' (Citations omitted.) Id.

In *Porter*, this court stated that ''questions about the methodological validity of proffered scientific testimony will generally go to the weight of such evidence, not to its admissibility. Courts should exclude scientific evidence, however, when such concerns render the technique, and the resulting evidence, incapable of assisting the fact finder in a sufficiently meaningful way.'' Id., 88. Furthermore, ''[a]s the court in *Daubert* noted, the focus of a validity assessment 'must be solely on principles and methodology, not on the conclusions that they generate.' '' Id., 81. ''So long as the methodology underlying a scientific opinion has the requisite validity, the testimony derived from that methodology meets the *Daubert* threshold for admissibility, even if the judge disagrees with the ultimate opinion arising from that methodology, and even if there are other methodologies that might lead to contrary conclusions.'' Id., 81–82.

We have held generally that ''[t]he trial court has broad discretion in ruling on the admissibility [and relevancy] of evidence. . . . The trial court's ruling on evidentiary matters will be overturned only upon a showing of a clear abuse of the court's discretion.'' (Citation omitted; internal quotation marks omitted.) *State* v. *Bruno*, 236 Conn. 514, 549, 673 A.2d 1117 (1996); see *State* v. *Sauris*, 227 Conn. 389, 406–407, 631 A.2d 238 (1993); see also *General Electric Co.* v. *Joiner*, 522 U.S. 136, 141–44, 118 S. Ct. 512, 139 L. Ed. 2d 508 (1997) (abuse of discretion standard of review applies to decision to admit or exclude evidence under *Daubert*). We conclude, consistent with these authorities, that a trial court's ruling on a *Porter* issue is subject to an abuse of discretion standard on appeal.

This court previously has considered the admissibility of nuclear DNA evidence; see *State* v. *Sivri*, 231 Conn. 115, 153–54, 646 A.2d 169 (1994) (restriction fragment length polymorphism process generally accepted); *State* v. *Skipper*, 228 Conn. 610, 613–24, 637 A.2d 1101 (1994) (DNA paternity probability based on Bayes' theorem unconstitutional); but neither of those cases addressed the issues raised by the present appeal, namely, the validity of the laboratory and statistical techniques used to analyze and interpret mitochondrial DNA evidence.[6] As we noted in reviewing the admissibility of nuclear DNA evidence in *State* v. *Sivri*, supra, 152–55, a three step process is used to compare nuclear DNA samples: (1) DNA is extracted and its sequence is represented on a graph; (2) the graphs are visually compared to determine if they match; and (3) statistical analysis is used to determine the significance of that match. We examine those same three steps to review the mtDNA evidence in this case.

1

We begin with a discussion of the procedures that

are used to extract and graph the chemical bases of mtDNA. In 1992, the National Research Council of the National Academy of Sciences assembled a committee of eminent scientists and jurists to address the concerns of the scientific, legal and forensic communities about the viability of DNA typing evidence. See Committee on DNA Technology in Forensic Science, National Research Council, ''DNA Technology in Forensic Science,'' (1992) pp. 1–2 (Committee report I); *State* v. *Sivri*, supra, 231 Conn. 158–59. The Committee report reviewed the techniques, including PCR, that allow comparison of DNA samples to establish a match, and the statistical methods used to explain the meaning of that match. Committee report I, supra, pp. 63–70, 75–95. In *Sivri*, we noted that ''the Committee report fully endorsed the DNA typing technology itself, even going so far as to recommend that courts take judicial notice of the scientific acceptability of the procedures used to extract and compare DNA alleles.''[7] *State* v. *Sivri*, supra, 159.

In 1996, the National Research Council of the National Academy of Sciences convened a second committee to review and update the information and conclusions of the 1992 report, specifically issues relating to the statistical calculation of population frequencies of DNA types. See Committee on DNA Forensic Science: An Update, National Research Council, ''The Evaluation of Forensic DNA Evidence,'' (1996) pp. 1–2 (Committee report II). The committee noted that, ''[i]n the reported cases, judges, with the exception of a few dissenters, have held PCR-based techniques sufficiently reliable to establish matches between samples, under both the general-acceptance and sound methodology standards.'' Id., pp. 177–78; id., p. 178 n.32 (listing cases). The committee concluded that ''PCR-based methods are prompt, require only a small amount of material, and can yield unambiguous identification of individual alleles. The state of the profiling technology . . . [has] progressed to the point where the admissibility of properly collected and analyzed DNA data should not be in doubt.'' Id., p. 36.

Accordingly, we agree with the trial court's conclusion that the procedures used to extract and chart the chemical bases of mtDNA—extraction, PCR amplification, capillary electrophoresis, and the use of an automated sequencing machine to generate a chromatograph—are scientifically valid and generally accepted in the scientific community. See also M. Holland & T. Parsons, ''Mitochondrial DNA Sequence Analysis—Validation and Use for Forensic Casework,'' 11 Forensic Sci. Rev. 22, 35 (1999) (citing articles as to validity of DNA extraction, PCR amplification and sequencing); M. Wilson et al., ''Extraction, PCR Amplification and Sequencing of Mitochondrial DNA from Human Hair Shafts,'' 18 Biotechniques 662 (1995). The trial court properly concluded that issues regarding con-

tamination are important and may bear on the weight of mtDNA evidence in a particular case; see *State* v. *Porter*, supra, 241 Conn. 88–89; but that those issues do not undermine the admissibility of the results of the mtDNA sequencing process used in this case.

2

The techniques described previously provide a graph of the questioned and known mtDNA sequences that then must be examined to determine if they match. Under the FBI protocol, two samples of mtDNA match when they share a common base at every position. This is not the same as an identical *pattern*. For example, if a sequence contained an A-T pair at a certain position, and another sample had only a T at that position, then that difference would not result in an exclusion by the FBI because the samples share a common base at that position. This match criterion accounts for heteroplasmy within individuals.

We reject the defendant's argument that, given Shields' testimony regarding heteroplasmy and the FBI match criteria, the trial court should not have admitted the mtDNA analysis presented at his trial. First, there was no evidence of heteroplasmy in either the known or questioned samples in this case. The defendant's known mtDNA sequence not only shared a common base at every position with the questioned sample, but also had exactly the same pattern at every position as that sample. Second, heteroplasmy, to the extent that it is present, would result in false exclusions, not false inclusions.[8] Finally, in peer-reviewed journals there are no published criticisms of the FBI mtDNA analysis because of either heteroplasmy or the FBI's matching criteria. As with contamination, questions about matching criteria and heteroplasmy may bear on the weight of mtDNA evidence, but they do not render it inadmissible when used to distinguish between classes of individuals.

3

As to the means to assess the significance of the mtDNA match, we stated in *State* v. *Sivri*, supra, 231 Conn. 156, that ''because a match between two DNA bands means little without data on probabilities, the calculation of statistical probabilities is an integral part of the process . . . .'' (Internal quotation marks omitted.) See Committee report I, supra, p. 74 (''[t]o say that two patterns match, without providing any scientifically valid estimate [or, at least, an upper bound] of the frequency with which such matches might occur by chance, is meaningless''); Committee report II, supra, p. 192 (''it would not be scientifically justifiable to speak of a match as [probative] of identity in the absence of underlying data that permit some reasonable estimate of how rare the matching characteristics actually are'').

Nuclear DNA may, except in cases of identical twins,

be considered unique to each human, and therefore a match of nuclear DNA samples is highly probative of identity. Committee report II, supra, p. 161. Mitochondrial DNA, on the other hand, is not a unique identifier because it is shared by individuals within a given maternal line. M. Holland & T. Parsons, supra, 11 Forensic Sci. Rev. 29. Because the frequencies of mtDNA types in the entire population are not known, statistical statements based upon a sample of a population may be used to estimate that frequency. Id., 31–32. That was done in the present case, and the defendant quarrels primarily with the means of doing so (using zero as the numerator rather than one). This goes to the weight of the evidence and not to its admissibility, however.

In this case, because mtDNA taken from the defendant and from hairs on the sweatshirt previously had not been seen in the FBI database of 1219 Caucasians at the time of trial in June, 1999,[9] Wilson provided an *estimated maximum frequency*; see M. Holland & T. Parsons, supra, 11 Forensic Sci. Rev. 32; see also Committee report I, supra, pp. 75–76 (described as ''upper confidence limit'' obtained using counting method); of the mtDNA type obtained from those samples.[10] He testified that, at a 95 percent ''confidence interval,''[11] 99.7 percent of the Caucasian population[12] could be excluded as the source of the questioned sample. Although Wilson did not provide the mathematical formula that he used to obtain this result, the article by Holland and Parsons provides a ''very conservative 'confidence limit from zero proportion' '' that gives the same result: $1 - \alpha^{1/N}$, where α equals 0.05 for a 95 percent confidence level. M. Holland & T. Parsons, supra, 32. In the present case, N = 1219. Solving the equation, $1 - (0.05^{1/1219})$ yields 0.002454, or approximately 0.25 percent, which is a ''conservative upper bound on the maximum frequency that [this] mtDNA type could reasonably have in the [Caucasian] population.'' Id. This results in the conclusion that, at a 95 percent confidence interval, approximately 99.7 percent of the Caucasian population does not share the defendant's mtDNA type.[13] We note, as did the trial court, that the defendant's expert, Shields, calculated that approximately 99.3 percent of the Caucasian population would be excluded from being the donor of the questioned sample. We conclude that the trial court did not abuse its discretion in ruling that the statistical methods used to derive that mtDNA type frequency in this case were scientifically valid and would have been helpful to the jury.

Wilson also testified as to the *maximum match probability*; id.; of three in 1000. This probability restates the estimated maximum match frequency in terms of how many persons, on average, would be expected to have the given mtDNA type out of a random sample. Wilson explained that, out of 1000 randomly selected persons, it could be expected that three persons would

share the same mtDNA type as the defendant. Wilson properly did not suggest that the maximum match probability means that the probability that *the defendant* was the source of the questioned sample is three in 1000. See Committee report II, supra, p. 133.

The trial court carefully considered all of the evidence and concluded that the proffered testimony of Wilson was statistically sound and that it was likely to be helpful to the jury in assessing the probative value of the mtDNA evidence. The trial court did not abuse its discretion in concluding that the statistical statements met the *Porter* threshold standard for admissibility.

B

The defendant also claims that the trial court should have excluded that mtDNA evidence because its probative value was outweighed by undue prejudice. We disagree.

At the trial, Wilson's testimony provided essentially the same information and opinion that he had provided in the *Porter* hearing. He explained mtDNA extraction, amplification through PCR, sequencing, and match criteria. He testified that according to the tests performed for the present case, the defendant could not be excluded as the source of the questioned sample from the sweatshirt. He told the jury that, at the 95 percent confidence interval, 99.7 percent of the Caucasian population could be excluded as the source of the questioned sample. He explained the FBI database and its relationship with the confidence interval. See footnote 11 of this opinion. Wilson conceded that the frequency was an estimate based upon the FBI database, and that it is not representative of the New London population. Wilson also testified that mtDNA does not positively identify individuals because everyone within a given maternal line would have the same mtDNA type.

Before Wilson had testified about the estimated maximum frequency, the defendant objected to that testimony on the ground that its probative value was outweighed by undue prejudice. The trial court overruled that objection.

During its charge to the jury, the court instructed the jury on the mtDNA evidence and carefully pointed out the differences between nuclear DNA results and mtDNA results.[14] During its deliberations, the jury sent a note to the court that presented two questions, the second of which concerned the mtDNA evidence. That question asked in relevant part: "[W]as DNA from the gloves and the sweatshirt a match to the [defendant's] known DNA sample? . . ." The trial court answered the jury's question as follows: "[A]fter conferring with counsel, I can tell you that there was no forensic testing on the gloves, and that the only mitochondrial DNA testing had to do with two hairs that were allegedly taken from the sweatshirt, and that was mitochondrial

DNA testing, not DNA testing, remembering the difference.''

We have said that ''scientific evidence, like all evidence, is properly excluded if its prejudicial impact outweighs its probative value, even if it is otherwise admissible.'' *State* v. *Porter*, supra, 241 Conn. 90. ''Although relevant, evidence may be excluded by the trial court if the court determines that the prejudicial effect of the evidence outweighs its probative value. . . . Of course, [a]ll adverse evidence is damaging to one's case, but it is inadmissible only if it creates undue prejudice so that it threatens an injustice were it to be admitted. . . . The test for determining whether evidence is unduly prejudicial is not whether it is damaging to the defendant but whether it will improperly arouse the emotions of the jury. . . . The trial court . . . must determine whether the adverse impact of the challenged evidence outweighs its probative value. . . . Finally, [t]he trial court's discretionary determination that the probative value of evidence is not outweighed by its prejudicial effect will not be disturbed on appeal unless a clear abuse of discretion is shown. . . . [B]ecause of the difficulties inherent in this balancing process . . . every reasonable presumption should be given in favor of the trial court's ruling. . . . Reversal is required only where an abuse of discretion is manifest or where injustice appears to have been done.'' (Citations omitted; internal quotation marks omitted.) *State* v. *Copas*, 252 Conn. 318, 329–30, 746 A.2d 761 (2000).

''There are situations where the potential prejudicial effect of relevant evidence would suggest its exclusion. These are: (1) where the facts offered may unduly arouse the jury's emotions, hostility or sympathy, (2) where the proof and answering evidence it provokes may create a side issue that will unduly distract the jury from the main issues, (3) where the evidence offered and the counterproof will consume an undue amount of time, and (4) where the defendant, having no reasonable ground to anticipate the evidence, is unfairly surprised and unprepared to meet it.'' *State* v. *DeMatteo*, 186 Conn. 696, 702–703, 443 A.2d 915 (1982); accord *State* v. *Greene*, 209 Conn. 458, 478–79, 551 A.2d 1231 (1988). In light of these examples, we find no merit to the defendant's claim.

The defendant argues that the jury was confused by the testimony about the meaning of a ''match'' as evidenced by its note to the judge during its deliberations. Although there is anecdotal evidence that juries may confuse mtDNA evidence with nuclear DNA; see L. Cohen, ''Innovative DNA Test Is an ID Whose Time Has Come for the FBI,'' Wall St. J., Dec. 19, 1997, p. 1; in the present case, Wilson's testimony, the trial court's instruction to the jury on the mtDNA evidence and the trial court's response to the jury's question regarding that evidence repeatedly distinguished mtDNA from

nuclear DNA testing.

The defendant further argues that the ''psychological effect on the jury'' of mtDNA evidence ''cannot be overstated,'' especially as the defendant did not present expert testimony to rebut the testimony of the state's expert. The concern is that jurors will overvalue DNA evidence and ignore other types of evidence. See Committee report II, supra, pp. 196–97; J. Schklar & S. Diamond, ''Juror Reactions to DNA Evidence: Errors and Expectancies,'' 23 Law & Hum. Behav. 159 (1999). One way to address that concern is an instruction to the jury on the need to consider all of the evidence in a case. See Committee report II, supra, p. 197. In the present case, the trial court instructed the jury that the mtDNA evidence was one type of evidence that they should consider and weigh just as they would other types of evidence. See footnote 14 of this opinion. We presume that the jury followed the court's instructions. See *State* v. *Porter*, supra, 241 Conn. 73.

Additionally, some research suggests that, while jurors are influenced by DNA evidence, they are not overwhelmed by that evidence. See Committee report II, supra, p. 197. Moreover, a defendant may offer an opposing expert or, as the defendant here did, use cross-examination to critique the analysis and interpretation of mtDNA evidence. Finally, we note that mtDNA evidence is similar to other types of class evidence such as blood type; see *Moore* v. *McNamara*, 201 Conn. 16, 27–29, 513 A.2d 660 (1986); and microscopic hair analysis; see *State* v. *Reid*, 254 Conn. 540, 544–49, 757 A.2d 482 (2000); that we traditionally have held is admissible in criminal trials.

After carefully reviewing the record, we conclude that the trial court properly admitted the expert testimony regarding mtDNA evidence. While the mtDNA evidence may have had a significant impact on the jury, that alone is not undue prejudice. See *State* v. *DeMatteo*, supra, 186 Conn. 703 (''[p]rejudice is not measured by the significance of the evidence which is relevant but by the impact of that which is extraneous'').

III

The defendant finally argues that the trial court improperly admitted as hearsay the testimony of Wilma Ahura in which Natalie Dantzler had told Ahura that the defendant had shown Dantzler ''a lot of money'' in his pants on the day of the robbery. We reject this claim.

At the trial, Dantzler testified that, on the day of the robbery, the defendant had arrived unexpectedly at Ahura's apartment where Dantzler was visiting. Dantzler testified that, while at Ahura's apartment, she had followed the defendant into the hallway and that the defendant, while asking her to go out with him, opened his sweatpants, revealing ''a lot'' of money. Ahura later testified that, while at her apartment, the defendant had

asked her if she had "seen the news." Ahura asked the defendant why he had asked her that, and the defendant said, "You'll find out." Ahura testified that, later that day, she watched the television news and learned that the Ocean Avenue branch of Citizens Bank had been robbed that morning. Ahura also testified that Dantzler had told her about the money in the defendant's pants. The defendant objected to the latter testimony on the ground that it was inadmissible hearsay. The state argued that Ahura's testimony of what Dantzler had told her was offered "as the context for certain observations the witness made later when she listened to the [television] news . . . and why certain aspects of that were significant to her."[15] The court overruled the defendant's objection, but instructed the jury that "the fact that Ms. Dantzler may have said something to [Ahura] is not to be taken as the truth of that statement . . . ." We conclude that the court's limiting instruction cured any prejudice to the defendant. See, e.g., *State* v. *Kelly*, 256 Conn. 23, 68, 770 A.2d 908 (2001) (any prejudice created by evidence was cured by trial court's limiting instruction to jury); *State* v. *Wargo*, 255 Conn. 113, 142, 763 A.2d 1 (2000).

The defendant's statement to Ahura about the news was offered to show that the defendant knew of the bank robbery before it was reported on the television news. See, e.g., *State* v. *Gray*, 221 Conn. 713, 723–24, 607 A.2d 391, cert. denied, 506 U.S. 872, 113 S. Ct. 207, 121 L. Ed. 2d 148 (1992) (statements or conduct evincing consciousness of guilt are relevant and admissible). We note that the effect on Ahura of then seeing the television news story because of what Dantzler had told Ahura was received without objection. See *State* v. *Carey*, 228 Conn. 487, 495–96, 636 A.2d 840 (1994). We conclude, therefore, that Dantzler's testimony properly was admitted.

Furthermore, evidentiary rulings will be overturned on appeal only upon a showing by the defendant of substantial prejudice or injustice. *State* v. *Alvarez*, 216 Conn. 301, 306, 579 A.2d 515 (1990). "[T]he burden to prove the harmfulness of an improper evidentiary ruling is borne by the defendant . . . [who] must show that it is more probable than not that the erroneous action of the court affected the result." (Internal quotation marks omitted.) *State* v. *McIntyre*, 242 Conn. 318, 329, 699 A.2d 911 (1997). Because Ahura's testimony was merely repetitive of Dantzler's own testimony, and because the trial court had advised the jury that it should not consider Ahura's statements for their truth, the defendant has not met his burden of demonstrating harm. See id., 329–30; *Bell Food Services, Inc.* v. *Sherbacow*, 217 Conn. 476, 490, 586 A.2d 1157 (1991) (inadmissible hearsay evidence merely cumulative of other properly admitted evidence and therefore unlikely to have affected trial court's judgment).

The judgment is affirmed.

In this opinion the other justices concurred.

* Although Chief Justice McDonald reached the mandatory age of retirement before the date that this opinion was officially released, his continued participation on this panel is authorized by General Statutes § 51-198 (c). The listing of justices reflects their seniority status on this court as of the time of oral argument.

[1] General Statutes § 53a-136 (a) provides: "A person is guilty of robbery in the third degree when he commits robbery as defined in section 53a-133."

General Statutes § 53a-133 provides: "A person commits robbery when, in the course of committing a larceny, he uses or threatens the immediate use of physical force upon another person for the purpose of: (1) Preventing or overcoming resistance to the taking of the property or to the retention thereof immediately after the taking; or (2) compelling the owner of such property or another person to deliver up the property or to engage in other conduct which aids in the commission of the larceny."

[2] General Statutes § 53a-123 (a) provides in relevant part: "A person is guilty of larceny in the second degree when he commits larceny, as defined in section 53a-119, and . . . (2) the value of the property or service exceeds five thousand dollars . . . ."

[3] The affidavit supporting the second search warrant stated the qualifications of the affiants and then provided: "That [at] approximately 9:56 am, October 7, 1994 a robbery of the Citizens Bank, 450 Ocean Ave., New London, Connecticut occurred. The suspect entered the bank, stated, 'This is a bank robbery,' and vaulted the tellers' counter. The suspect again announced, 'This is a bank robbery,' and removed currency from several teller drawers. The suspect then fled the scene.

"That at the time of the robbery bank tellers were at their assigned stations, and patrons were present. The bank manager, Donna Stefanski, stated that she heard the suspect announce the robbery and vault the counter. At that time she observed the tellers quickly back away from their stations. That Dana Chapel, a teller, heard a coworker exclaim, to the effect, 'Oh, my God.' Upon hearing that statement Chapel turned, and observed the suspect removing currency from a teller drawer. That patron, Barbara Bentley, stated that as the robbery occurred she became so frightened that she hid in a corner until told by someone that the robbery was over.

"That the suspect's conduct created fear among the employees and patrons which aided him in the commission of the larceny.

"That as the suspect removed currency from the drawers he stuffed it into what appeared to be the front of his pants, shirt, and sweatshirt.

"That the suspect was described as a white male, approximately twenty five years of age, 5'4 to 5'8, medium build, brown colored hair, with a prominent nose. He wore dark colored foot wear, aqua colored gloves, and a blue or gray colored hooded sweatshirt. The suspect appeared to wear multiple layers of clothing.

"That the suspect removed from the bank five thousand five hundred and thirty dollars.

"That the suspect fled from the bank to railroad tracks. Responding police units observed the suspect in flight along those tracks, and an immediate perimeter was secured. The subsequent police search of the railroad tracks led to the discovery of a pair of gloves, a sweatshirt, and in excess of two thousand dollars in currency. Serial numbers and wrappings identified that currency as having been stolen from the Citizens Bank. The gloves and sweatshirt were identified by bank tellers involved as appearing similar to those worn by the suspect.

"That the gloves and sweatshirt were forwarded to the [FBI] for laboratory examination. That agency subsequently identified hairs on the gloves and sweatshirt, and preserved those hairs for future comparison.

"That the aforementioned perimeter which police secured while the suspect was visible to officers enclosed an area which extended west from the bank into an extensive, and wooded and marshy territory, and south from Dell Ave., which abuts the railroad tracks, to Evergreen Ave. which is one block south of the bank. The securing of that perimeter was immediate upon the sighting by officers of the suspect, and included the use of a helicopter. That perimeter was released by police approximately 2:00 pm that date after an unsuccessful search for the suspect.

"That [the defendant] was developed as a suspect during the robbery investigation. He is of the approximate age, height, and build as witnesses described the suspect. [The defendant] also has brown colored hair, and a

prominent nose as witness, Linda Schwartz, described the suspect.

"That witness, Linda Schwartz, viewed a photographic array which consisted of twelve photographs of white males of similar appearance, and which included a photograph of [the defendant]. Schwartz immediately, and positively identified the photograph of [the defendant] as depicting the subject who had committed the robbery of Citizens Bank.

"That Wilma Ahura, at the time of the robbery, resided at 239 Apt. 241 Nautilus Dr., New London, Connecticut. Nautilus Drive is one block south of Evergreen Ave., the south border of the police perimeter during the initial police response to the robbery. She was interviewed by agents of the [FBI] and stated that approximately 4:30 to 5:00 pm, on the date of the robbery she was visited at her residence by [the defendant]. She described [the defendant] as, 'real nervous,' and, 'soaked.' [The defendant] asked, to the effect, 'Did you hear anything on the news?' When Ahura asked what had happened, [the defendant] responded, 'Well, you'll hear it on the news.' Ahura stated that [the defendant's] pants and stomach area appeared, 'stuffed,' with something.

"That Natalie Dantzler stated she had been visiting Ahura when [the defendant] arrived at the Nautilus Dr. Apartment. She added that [the defendant] was wearing a blue colored sweatshirt with a front pocket, and he appeared, 'sweating or wet.' Dantzler stated that [the defendant] attempted to persuade her to accompany him to a motel room. He pulled open the waist band of his sweatpants and Dantzler observed, 'a lot of money,' 'crunched and balled up,' and that she had never seen that much money before. She stated that he appeared to wear multiple layers of clothing. [The defendant] told Dantzler that he and a friend had stolen about five thousand dollars from a drug dealer. She added that it was unusual to see [the defendant] walking as it is customary for him to have vehicle transportation.

"That as described by Ahura and Dantzler, [the defendant] would appear 'sweating or wet,' and 'soaked,' had he entered and secreted himself in the wooded and marshy area which had been cordoned off by police earlier that day.

"That Walter Snyder was interviewed by agents of the [FBI] on January 11, 1995. He told those agents that approximately four months earlier [the defendant] had asked him to participate in a bank robbery, but that he, Synder, had declined. Snyder added that sometime after that conversation [the defendant] had come into possession of, 'A bunch of money,' and that [the defendant] had spent the money on cocaine.

"That your affiants know [the defendant] to have an extensive criminal arrest history which dates to 1981.

"That based on their training and experience your affiants know that hairs from the human body are routinely transferred to clothing, and that laboratory examination will identify similarities in the hairs discovered on clothing and a person's head hair.

"That on February 5, 1996 a search and seizure warrant was issued for the recovery of hairs from the body of [the defendant]. On February 7, 1996 that warrant was executed, and pulled hairs from the body of [the defendant] were forwarded to the [FBI] laboratory for examination.

"That on June 28, 1996 Special Agent Lisa Tutty of the [FBI] was contacted by an examiner of the [FBI] laboratory regarding the pulled hairs from the body of [the defendant]. Special Agent Tutty was advised that similarities existed in those hairs and hairs recovered on suspect clothing. But, in order to conduct the analysis requested 'naturally shed' head hairs, rather than pulled head hairs of [the defendant] were required. The examiner explained that hairs on the suspect clothing had been 'naturally shed,' and as such head hairs of [the defendant] obtained by hair combing should be submitted for comparison.

"That due to the facts documented in this affidavit your affiants believe that combed hairs from the head of [the defendant], a white male, date of birth, May 7, 1964 possess evidence of the crime of robbery 3rd, [§] 53a-136."

[4] Wilson testified that all Caucasians have the same distribution of mtDNA types and thus additional subgroupings of Caucasians are not necessary.

[5] The transcript of Shields' testimony quotes him as having said "point 993." The trial court, however, in ruling on the motion in limine, noted that Shields had said 99.3 percent, and neither the state nor the defendant has challenged the trial court's description of his testimony.

[6] All of the state appellate courts that have considered the methodology of mtDNA analysis in criminal trials thus far have concluded that it is scientifically valid and admissible. See *State* v. *Underwood*, 134 N.C. App. 533, 542–43, 518 S.E.2d 231 (1999) (under *Daubert* standard); *State* v. *Coun-*

cil, 335 S.C. 1, 19, 515 S.E.2d 508 (1999) (under state law standard similar to *Daubert* factors); *State* v. *Scott*, 33 S.W.2d 746, 759 (Tenn. 2000) (under state rules of evidence and statute). Many trial courts also have concluded that mtDNA evidence is reliable. See, e.g., *People* v. *Klinger*, 185 Misc. 2d 574, 585, 713 N.Y.S.2d 823 (2000) (listing other cases); but see *State* v. *Crow*, 18th Cir. Ct. of Florida, Docket No. 96-1156-CFA (1998) (concluding under *Frye* v. *United States*, 293 F. 1013 [D.C. Cir. 1923] that presentation of results of mtDNA based on number of observations in database would confuse jury).

[7] An ''allele'' is defined as ''one or two or more alternative forms of a gene. In DNA analysis the definition is extended to any DNA region used for analysis.'' Committee on DNA Forensic Science: An Update, National Research Council, ''The Evaluation of Forensic DNA Evidence,'' (1996) p. 214.

[8] When heteroplasmy *is* present, it may aid in the assessment of whether two sequences match. M. Holland & T. Parsons, supra, 11 Forensic Sci. Rev. 26. For example, ''[i]f a reference sample and an unknown sample match each other by sharing a constellation of unusual polymorphisms, the co-occurrence of heteroplasmy at a particular site would provide additional evidence restricting the pool of potential donors . . . .'' Id.

[9] The database that the FBI uses is a convenience sample derived from ''paternity cases, blood banks, hospitals,'' and a variety of other sources. Although convenience samples may be biased; see Committee report II, supra, p. 186; there was no evidence of bias in the FBI database in the present case. Cf. *United States* v. *Jakobetz*, 747 F. Sup. 250 (D. Vt. 1990), aff'd, 955 F.2d 786 (2d Cir.), cert. denied, 506 U.S. 834, 113 S. Ct. 104, 121 L. Ed. 2d 63 (1992) (sample consisting of FBI agents criticized).

[10] Usually a statistical estimate based upon a random sample would be presented as a range within which the ''true'' value is expected to fall. See Federal Judicial Center, Reference Manual on Scientific Evidence (2d Ed. 2000) pp. 117–18; M. Holland & T. Parsons, supra, 11 Forensic Sci. Rev. 32. For example, the range of the *estimated* frequency of an mtDNA type may be from 0 percent to 3 percent, where 3 percent is the maximum ''upper bound'' value. See M. Holland & T. Parsons, supra, 32. It is this ''upper bound'' that the committee in Committee report I discusses as deriving from the ''counting method.'' See Committee report I, supra, pp. 75–76; see also footnote 13 of this opinion. Because the *actual* frequency of rare mtDNA types ''in a great majority of cases would be much lower'' than the maximum upper bound, the upper bound provides a conservative estimate of the frequency of mtDNA types that have not yet been observed in a database. M. Holland & T. Parsons, supra, 32.

The counting method is not preferred for calculating random match probabilities for nuclear DNA because nuclear DNA have multiple loci that may be analyzed separately and multiplied using the ''product rule''; Committee report II, supra, p. 111; and the counting method does not take full advantage of that information. Id., p. 159. Because mtDNA consists of only one marker, or locus, that critique of the counting method does not apply to mtDNA.

[11] An mtDNA type frequency based upon a sample is an estimate of the actual prevalence of that type, and as with any estimate, there is some uncertainty owing to the possibility of random error. See Federal Judicial Center, Reference Manual on Scientific Evidence (2d Ed. 2000) p. 117; Committee report II, supra, p. 146. A ''confidence interval'' describes that uncertainty. Federal Judicial Center, supra, pp. 117–18. It does not establish the probability that the estimate is correct. See id., p. 119 n.118; 1 C. McCormick, Evidence (5th Ed. 1999) § 208, p. 796. For example, a frequency estimate that excludes 99.7 percent of a given population with a confidence interval of 95 percent *does not* mean that the 99.7 percent figure has a 95 percent probability of being the correct or ''true'' frequency. Rather, a confidence interval ''gives the percentage of the time that intervals from repeated samples will cover the true value.'' Federal Judicial Center, supra, p. 119 n.118. ''Thus, the 'confidence' pertains to the *process* rather than to any particular *result*.'' (Emphasis added.) 1 C. McCormick, supra, p. 797.

We note that the idea that a confidence interval expresses a degree of uncertainty in the method used to obtain an estimated maximum frequency was properly explained to the jury in this case.

[12] Of course, the estimated maximum frequency, 99.7 percent, is *not* the probability that the *defendant* was the source of the questioned sample. The determination of the probability that a particular defendant is the source of DNA evidence requires the use of Bayes' theorem, a mathematical formula in common use by statisticians; see Committee report II, supra, pp. 132–33; which we rejected in *State* v. *Skipper*, supra, 228 Conn. 623–24.

[13] An "upper bound" calculated by using the "counting method" as described in Committee report I apparently would obtain the same result. In Committee report I, the committee described the counting method as follows: "A standard way to estimate frequency is to count occurrences in a random sample of the appropriate population and then use classical statistical formulas to place upper and lower confidence limits on the estimate. Because estimates used in forensic science should avoid placing undue weight on incriminating evidence, *an upper confidence limit of the frequency should be used in court*." (Emphasis added.) Committee report I, supra, p. 75. For example, "[i]f the pattern occurred in 0 of 100 samples, the estimated frequency would be 0%, with an upper confidence limit of 3%. (The upper bound cited is the traditional 95% confidence limit . . . .)" Id., p. 76. Using the formula provided by Holland and Parsons, if N = 100, then $1 - (0.05^{1/100})$ equals 0.0295, or approximately 3 percent, the same upper bound value obtained in the Committee report I example. See id., p. 75.

[14] The trial court instructed the jury with respect to the mtDNA evidence as follows: "Now in this case, the state has introduced evidence concerning mitochondrial DNA. As Agent Wilson's testimony indicated, mitochondrial DNA evidence differs from the more commonly known nuclear DNA in its location, its sequence and its mode of inheritance.

"Mitochondrial DNA also differs from nuclear DNA in that mitochondrial DNA is not unique to any one individual. For example, everyone in a maternal line will share the same mitochondrial DNA. Instead, mitochondrial DNA is what is known as class evidence.

"You are to consider the mitochondrial DNA evidence in this case giving it the weight that you deem appropriate. However, you must remember that nuclear DNA evidence is entirely different and nuclear DNA evidence is not involved in this case.

"Finally, like any evidence, mitochondrial DNA evidence is for you to consider, along with other circumstances in the case in using your best judgment to determine whether or not you will give any weight to it; and if so, what weight you will give to it."

[15] In response to questioning by the state's attorney, Ahura testified as follows:

"[State's Attorney]: You indicated that Ms. Dantzler and [the defendant] were in the hallway and Ms. Dantzler then returned alone into the apartment; is that correct?

"[Ahura]: Yeah.

"Q. What did Ms. Dantzler say to you when she returned to the apartment?

"A. She said he asked her if she wanted to go out.

"Q. And did she say—tell you anything that she observed?

"A. Yeah. He showed her some money.

"Q. She indicated that he showed her some money. Did she indicate how much money?

"A. A lot. . . .

"Q. Did she indicate where the money was?

"A. In his pants. . . .

"Q. [The defendant] asked you earlier if you had seen the news, had he not?

"A. Yes.

"Q. And did you see any news later that day?

"A. Yes.

"Q. And was there anything on the news that you thought was particularly significant in light of everything that had happened that day and what Ms. Dantzler had told you?

"A. Yes.

"Q. What was on the news?

"A. That a bank was robbed on Ocean Avenue.

"Q. On Ocean Avenue?

"A. Yes.

"Q. That was the day the bank was robbed on Ocean Avenue?

"A. Yeah.

"Q. Did that mean anything to you in particular in context with what had happened earlier?

"A. Well, I thought about it. I thought that a lot of money, you know, that's the first thing that comes to your mind. We are in the same area."