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Mitochondrial DNA: Emerging Legal Issues

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INTRODUCTION

Mitochondrial DNA (mtDNA) is an exciting and important new development in forensic technology.[1] Compared with traditional nuclear DNA (nDNA) analysis, mtDNA offers three primary benefits.[2] First, its structure and location in the cell make mtDNA more stable, enabling investigators to test old or degraded samples.[3] Second, mtDNA is available in larger quantities per cell,

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[1] The first use of mtDNA in a criminal case was in 1996 in Tennessee. *See* Mark Curriden, *A New Evidence Tool: First Use of Mitochondrial DNA Test in a U.S. Criminal Trial*, 82 A.B.A. J. 18, at 18 (1996). *See also* Julian Adams, *Nuclear and Mitochondrial DNA in the Courtroom*, 13 J.L. & POL'Y 69 (2005).

[2] *See generally* Marlan D. Walker, *Mitochondrial DNA Evidence in* State v. Pappas, 43 JURIMETRICS J. 427, 428–31 (2003) (discussing the admissibility of mtDNA evidence in court, the scientific principles underlying it, and the laboratory procedures involved).

[3] Alice R. Isenberg, *Forensic Mitochondrial DNA Analysis: A Different Crime-Solving Tool*, 71 FBI L. ENFORCEMENT BULL. 8, at 16 (2002) (noting that mtDNA's location in the cell and its circular structure "protect[] it from deterioration"); Charlotte J. Word, *The Future of DNA Testing and Law Enforcement*, 67 BROOK. L. REV. 249, 251 (2001) (reporting mtDNA's use in post-conviction cases and other cases in which samples are very old).

enabling the testing of smaller samples.[4] Finally, and perhaps most importantly, mtDNA can be extracted from samples in which nDNA cannot, specifically bone fragments and hair shafts.[5]

At the same time, however, the evidentiary weight of mtDNA is not equivalent to that of nDNA. While the laboratory techniques involved in analyzing the two types of DNA are nearly identical, their probative values are quite different. For example, unlike with nDNA, maternal relatives share identical copies of mtDNA, so mtDNA is not a unique identifier.[6] In addition, because mtDNA is still in its infancy as a forensic tool, definitive population statistics are not yet available on the various alleles (or sequences). This issue is sure to dissipate as mtDNA databanks become larger and more comprehensive but, until then, the probative value of an mtDNA "match" may be somewhat ambiguous.

This article will briefly survey some of the current and emerging legal issues surrounding mtDNA evidence. Parts I and II discuss basic evidentiary questions, including mtDNA's reliability and admissibility under *Daubert*[7] as well as the potential problem of jury confusion regarding the probative value of mtDNA. Part III considers the broader potential of mtDNA to supplant microscopic hair analysis, a technique often criticized for its subjectivity and high error rate. Finally, Part IV explores the unique privacy concerns raised by the maternal inheritance of mtDNA, specifically in the context of DNA databanks.

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[4] State v. Council, 515 S.E.2d 508, 516 & n.12 (S.C. 1999).

[5] United States v. Coleman, 202 F. Supp. 2d 962, 965 (E.D. Mo. 2002) (observing that bone and hair shafts can be tested for mtDNA); Word, *supra* note 3, at 251 (noting the use of mtDNA in testing hair shafts and dried bones because they cannot be tested for nDNA).

[6] *See* Walker, *supra* note 2, at 429 (discussing the maternal inheritance of mtDNA); Isenberg, *supra* note 3, at 16 (noting that mtDNA is strictly inherited from the maternal line).

[7] Daubert v. Merrell Dow Pharm., 509 U.S. 579, 585-97 (1993) (holding that the general acceptance of a scientific technique is not a precondition for admission of expert testimony based upon that technique so long as the standards of reliability and relevance under the Federal Rules of Evidence are met).

I. RELIABILITY

Is mtDNA sufficiently reliable to be admissible? For courts across the country, the answer has been a clear and resounding yes. A glance at recent case law shows that mtDNA has quickly gained judicial approval in both federal and state courts.[8] Indeed, admissibility has become so common that the number of admissibility hearings for mtDNA has decreased substantially in recent years.[9]

A significant minority of states have statutorily declared DNA evidence admissible,[10] and a number of courts have taken judicial

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[8] *E.g.*, United States v. Beverly, 369 F.3d 516, 530 (6th Cir. 2004) (finding that the district court did not abuse its discretion in admitting mtDNA); *Coleman*, 202 F. Supp. 2d at 970 (holding mtDNA to be clearly scientific and admissible); State v. Pappas, 776 A.2d 1091, 1111 (Conn. 2001) (upholding trial court's admission of mtDNA); Wagner v. State, No. 2034, 2005 WL 14913, at *5 (Md. Ct. Spec. App. Jan. 3, 2005) (same); People v. Holtzer, 660 N.W.2d 405, 410 (Mich. Ct. App. 2003) ("[T]he case for mtDNA is strengthening with time, not weakening."); Adams v. State, 794 So. 2d 1049, 1065 (Miss. Ct. App. 2001) (holding that mtDNA satisfied all procedural safeguards); State v. Underwood, 518 S.E.2d 231, 240 (N.C. Ct. App. 1999) (upholding the trial court's admission of mtDNA); State v. Council, 515 S.E.2d 508, 518 (S.C. 1999); State v. Scott, 33 S.W.3d 746, 759 (Tenn. 2000) (finding mtDNA covered by a state statute declaring DNA evidence admissible). *See generally* 3 DAVID L. FAIGMAN ET AL., MODERN SCIENTIFIC EVIDENCE § 25-1.2.1 (2d ed. 2003) (cataloging mtDNA admissibility decisions); CONSTANCE L. FISHER ET AL., LAB. DIV., FED. BUREAU OF INVESTIGATION, PUBLICATION NO. 01-05, MITOCHONDRIAL DNA: TODAY AND TOMORROW 2 (2001) (reporting that mtDNA evidence is admissible in 26 states: Alabama, Arkansas, California, Connecticut, Florida, Georgia, Hawaii, Illinois, Indiana, Kansas, Louisiana, Maryland, Michigan, Minnesota, New Mexico, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Texas, Tennessee, Vermont, Virginia, Washington, and West Virginia); Erica Beecher-Monas, *The Heuristics of Intellectual Due Process: A Primer for Triers of Science*, 75 N.Y.U. L. REV. 1563, 1656 n.542 (2000) (citing Leigh Jones, *Type of DNA Ruled Reliable in Rape Trial*, N.Y. L.J., Sept. 7, 2000, at 1) (stating that Maryland, Michigan, New York, North Carolina, Pennsylvania, Tennessee, and the Eastern District of Ohio have found mtDNA to be reliable).

[9] FISHER, *supra* note 8, at 2 (noting that admissibility hearings concerning mtDNA have fallen off in recent years).

[10] CONN. GEN. STAT. ANN. § 54-86k(a) (West 2005); DEL. CODE ANN. tit.

notice of new DNA techniques.[11] Stretching these determinations to cover mtDNA automatically, however, is probably unwise.[12] Like all new technologies, mtDNA should be assessed on its own terms and not merely "lump[ed] together" with existing forms of DNA identification because it technically fits within the language of an admissibility statute or governing precedent.[13]

That said, however, courts have good reasons to accept mtDNA.[14] As a forensic tool with applications beyond litigation, mtDNA has been employed in nonadversarial contexts, such as the identification of historical remains,[15] war crime victims,[16] and the

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29, § 4713(a) (2004); IND. CODE. ANN. § 35-37-4-13(b) (West 2004); MINN. STAT. ANN. § 634.25 (West 2004); N.D. CENT. CODE § 31-13-02 (2003); TENN. CODE ANN. § 24-7-118(b)(1) (2004); VA. CODE ANN. § 19.2-270.5 (Michie 2004); *see also Scott*, 33 S.W.3d at 757–58 & n.10 (reporting states that, as of 2000, had enacted DNA admissibility statutes).

[11] United States v. Coleman, 202 F. Supp. 2d 962, at 968 (E.D. Mo. 2002) (noting that the Eighth Circuit takes judicial notice of the reliability of various nDNA techniques); *see also* United States v. Beasley, 102 F.3d 1440, 1445 (8th Cir. 1996) (taking judicial notice of DNA-PCR).

[12] *But see Scott*, 33 S.W.3d at 758–59 (holding that the state's DNA admissibility statute applied to mtDNA and refusing to hold an admissibility hearing because the statute made the reliability issue moot).

[13] *See, e.g.*, 3 FAIGMAN ET AL., *supra* note 8, at § 25-1.2.1 (arguing that "one should not lump all forms of DNA identification together" and that the principles of each new technology should be examined afresh for compliance with scientific reliability standards); Edward J. Imwinkelried & D.H. Kaye, *DNA Typing: Emerging or Neglected Issues*, 76 WASH. L. REV. 413, 459 (2001) (arguing that prior acceptance of another DNA methodology "does not dictate the conclusion that the court also must accept . . . mitochondrial DNA sequencing"); *see also Coleman*, 202 F. Supp. 2d at 965–66 (noting that mtDNA has had "little judicial scrutiny").

[14] *See* Margaret A. Berger, *Expert Testimony in Criminal Proceedings: Questions Daubert Does Not Answer*, 33 SETON HALL L. REV. 1125, 1137 (2003) (suggesting that mtDNA clearly meets the *Daubert* standard).

[15] David H. Kaye & George F. Sensabaugh, Jr., *Reference Guide on DNA Evidence*, *in* ANNOTATED REFERENCE MANUAL ON SCI. EVIDENCE 485, 493–97 (David L. Faigman et al., eds., 2004) (citing Peter Gill et al., *Identification of the Remains of the Romanov Family by DNA Analysis*, 6 NATURE GENETICS 130 (1994)).

[16] Ana Marusic, *DNA Lab Helps Identify Missing Persons in Croatia and*

victims of the September 11th attacks.[17] More importantly, mtDNA testing rests on essentially the same principles and procedures that underlie nDNA testing,[18] a technique now universally regarded as reliable.[19] Mitochondrial DNA laboratories have benefited from years of acquired wisdom in handling and processing nDNA, so even early on, many mtDNA labs had the protocols, standards, and proficiency testing necessary to ensure reliability.[20]

As with other forms of expert evidence, the mtDNA testing performed in a particular case can be challenged. Federal Rule of Evidence 702 requires that expert evidence not only be the "product of reliable principles and methods," but also that those principles and methods be applied "reliably to the facts of the case."[21] Thus, while mtDNA evidence may be sound as a general

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Bosnia and Herzegovina, 358 LANCET 1243 (2001) (reporting the use of nDNA and mtDNA for identifying persons in the Balkans); *see also* Beecher-Monas, *supra* note 8, at 1651 (reporting that mtDNA was used to identify bodies in the Balkans and the body of Tsar Nicholas II).

[17] *Coleman*, 202 F. Supp. 2d at 969–70; Bill Scanlon, *A Fast, Cheap DNA Match; Denver Scientists Develop New Way to Analyze Genetics*, ROCKY MOUNTAIN NEWS, July 13, 2002, at 8B.

[18] *Coleman*, 202 F. Supp. 2d at 969 (noting that the mtDNA process is the same as nDNA); *id.* (quoting Dr. Terry Melton, President of Mitotyping Technologies) (reporting that mtDNA involves the same machine and principles as nDNA).

[19] Imwinkelried, *supra* note 13, at 414 (suggesting that any question about the "validity of forensic [nuclear] DNA testing has largely dissipated").

[20] U.S. v. Coleman, 202 F. Supp. 2d 962, at 969 (E.D. Mo. 2002) (discussing the six weeks of validation studies used at a major mtDNA laboratory and the use of peer review since 1991); Berger, *supra* note 14, at 1134 (observing that the same laboratories perform mtDNA and nDNA testing). On the issue of peer review, Emory University has compiled a comprehensive listing of published mtDNA articles. *See* D.C. Wallace & M.T. Lott, References of Mitochondrial Interest, *at* http://www.mitomap.org/mitomap/biglist.html (last visited Feb. 2, 2005).

[21] FED. R. EVID. 702 (2004); *Coleman*, 202 F. Supp. 2d at 968 (noting that judicial notice does not end the admissibility inquiry and that the court can still look into whether the techniques were properly performed); Beecher-Monas, *supra* note 8, at 1652–54 (discussing the importance of checking the methodology used in mtDNA).

matter, the well-accepted procedures underlying mtDNA testing may be improperly applied in a given case.[22] Some courts, however, have classified case-specific problems as going to weight rather than admissibility[23]—a practice often observed in traditional DNA cases.[24]

II. PROBATIVE VALUE

Although the procedures for extracting and sequencing mtDNA are essentially the same as those used in traditional nDNA testing, the probative value of mtDNA evidence is quite different.[25]

A. Population Frequencies

Unlike nDNA, mtDNA sequences are commonly shared by multiple persons in the population.[26] The frequency of the most

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[22] 3 FAIGMAN ET AL., *supra* note 8, at § 25.1.2.1 (criticizing the decision in Sheckells v. State, No. 05-00-00660-CR., 2001 WL 1178828 (Tex. Ct. App. Oct. 8, 2001) (unpublished opinion) for not addressing the case-specific weaknesses raised by the defense, including the mtDNA expert's incompetence and sloppiness).

[23] *E.g.*, Wagner v. State, No. 2034, 2005 WL 14913, at *6 (Md. Ct. Spec. App. Jan. 3, 2005) (holding that contamination issues "affect[] the weight of mtDNA evidence, but [do] not automatically render mtDNA evidence inadmissible); State v. Pappas, 776 A.2d 1091, 1109 (Conn. 2001) (same). Contamination is almost always a risk in DNA testing, particularly when samples are amplified using PCR, but laboratories have well-established procedures to minimize the risk. FISHER, *supra* note 8.

[24] *Cf.* Berger, *supra* note 14, at 1129 (reporting that "courts are now so convinced that DNA evidence is admissible that they generally treat all challenges as going to the weight of the evidence," but arguing that exclusion may be proper for extreme cases such as laboratory fraud).

[25] *See* Adams, *supra* note 1.

[26] Mitochondrial DNA is currently only sequenced within two "hypervariable" regions, known as HV1 and HV2, which consist of 610 base pairs; in comparison, modern nuclear DNA testing uses thirteen sequence areas. *See* NAT'L COMM'N ON THE FUTURE OF DNA EVIDENCE, THE FUTURE OF FORENSIC DNA TESTING: PREDICTIONS OF THE RESEARCH AND DEVELOPMENT WORKING GROUP 19 (Nat'l Inst. of Justice 2000). Some commentators predict that future developments in mtDNA technology will enable other regions to be

common mtDNA sequence is approximately one in twenty-five,[27] whereas the frequency of an nDNA profile is estimated at one in ten billion.[28]

An mtDNA "match" is therefore clearly not the same as an nDNA "match."[29] With a traditional, nuclear DNA match, the jury can be reasonably certain that the biological material found at a crime scene came from the matched party. With a mitochondrial DNA match, however, contribution from the "matched" person is only made more likely.[30] As such, finding the suspect's mtDNA at a crime scene operates more akin to finding the suspect's blood type or brand of cigarette. To be sure, mtDNA sequences, being more uncommon, are more probative, but they are far less unique than nuclear DNA.

This critical difference between mtDNA and nDNA can create unfair prejudice problems. Defense attorneys may complain that jury members will misinterpret the mtDNA evidence, ascribing to it far more probative value than it deserves. Nonetheless, provided

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tested, making mtDNA a more powerful identification tool. *See* Fisher, *supra* note 8, at 4 (predicting the future use of single nucleotide polymorphisms—single base pair differences—of which there are probably sixty sites).

[27] *Pappas*, 776 A.2d at 1104; Berger, *supra* note 14, at 1135. Because mtDNA is still in its infancy, the population frequency estimates are undergoing constant revision as more samples are added to the database. *Compare* Berger, *supra* note 14, at 1135 (reporting that, as of 2002, the most common sequence had a frequency of 4%), *with* Fisher, *supra* note 8, at 3 (reporting in July 2000 a frequency of 7%). Indeed, because the database size is still so small, *Coleman*, 202 F. Supp. 2d at 967 (reporting that the FBI database contained 4,142 entries in 2002), the FBI does not provide official population frequency estimates, but rather only reports absolute numbers (i.e., how many times the sequence appears in the database), Isenberg, *supra* note 3, at 16. Statistical methods, however, enable the calculation of the upper-bound for the estimated population frequencies; these estimates will become more precise as the database grows. *Id.*

[28] Berger, *supra* note 14, at 1128.

[29] Exclusion, in contrast, works the same for mtDNA and nDNA. If a suspect's mtDNA or nDNA is different from the material recovered at the crime scene, then the suspect is plainly excluded.

[30] For this very reason, mtDNA experts generally testify only that the suspect "cannot be excluded" from the pool of contributors, rather than use the loaded term "match."

that jurors are sufficiently educated about mtDNA's differences and limitations, there is little reason why they could not appropriately distinguish the two technologies.[31]

B. Maternal Relatives

A related complication is the problem of maternal relatives. Each person's nuclear DNA is a combination of paternal and maternal DNA, ensuring that the nDNA profiles of family members and relatives are distinguishable (albeit similar). Not so for mtDNA, which is passed solely from mother to child. Consequently, all maternal relatives share identical mtDNA and thus cannot be distinguished from one another on this basis.[32]

This linkage issue can cause problems when maternal relatives are also suspects. The presence of a known maternal relative can change the probative value of mtDNA evidence significantly. For one thing, the general population frequencies are no longer applicable because the rarity of the mtDNA sequence is irrelevant to a jury deciding between two maternal relatives.[33]

While maternal linkage may cause difficulties in rare instances, it will not present a serious problem as a general matter. Provided that jurors are made aware of the maternal linkage issue,[34] mtDNA's probative value will be in narrowing the pool of potential suspects. The mtDNA evidence will thus be hardly different from finding a straight black hair at the crime scene when both relatives have straight black hair. Generally speaking, it will be part of a broader body of evidence, and the other evidence will

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[31] U.S. v. Coleman, 202 F. Supp. 2d 962, at 970–71 (E.D. Mo. 2002) (holding that no Rule 403 problem existed when an mtDNA expert's testimony explained that mtDNA cannot create an exact match).

[32] Isenberg, *supra* note 3, at 17 (observing that mtDNA cannot establish a precise match because of the maternal-relatives problem).

[33] Berger, *supra* note 14, at 1135–36 (noting that population statistics are not relevant if maternal relatives live nearby).

[34] Defense attorneys naturally bear the primary responsibility for making jurors aware of the limitations of mtDNA evidence. However, given the limited availability of defense experts and defense attorneys' potential lack of familiarity with the technology, courts could require that mtDNA experts testify about mtDNA's limitations as a condition of admissibility.

make one relative more likely to be the perpetrator than the others. When such additional inculpatory evidence does not exist, courts could justifiably decide that the mtDNA evidence, standing alone, is insufficient for conviction.[35]

III. MICROSCOPIC HAIR ANALYSIS AND A "BEST SCIENCE" RULE

The scientific rigor that accompanies the mtDNA testing process, coupled with the test's ability to extract identifying information from hair shafts, enables us to examine a slowly developing issue in scientific evidence. On the whole, discussions about scientific evidence have focused on *Daubert*, which conceptually assesses scientific evidence on an absolute scale. Either a forensic technology or scientific finding is "reliable," or it is not; there is little (overt) discussion about the relative merits of a given technique vis-à-vis other available technologies.

This Part discusses the ramifications that mtDNA analysis may have for the continued use and admissibility of traditional microscopic hair analysis, which has been the subject of much recent criticism. Pressing further, this article asks whether courts might actually require mtDNA in the place of microscopic hair analysis and speculates about the effects of applying a "Best Science Rule" to the admission of scientific evidence generally.

A. Microscopic Hair Analysis

Microscopic hair analysis has been used since the nineteenth

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[35] Berger, *supra* note 14, at 1136 (noting reasonable doubt problems that arise because of the possibility that a relative was the perpetrator). For example, because microscopic hair analysis is similarly not conclusive of identity, some courts have found that microscopy by itself is insufficient for a conviction. *E.g.*, State v. Stallings, 334 S.E.2d 485, 486 (N.C. Ct. App. 1985) (holding that microscopy "must be combined with other substantial evidence to take a case to the jury"); *see also* Clive A. Stafford Smith & Patrick D. Goodman, *Forensic Hair Comparison Analysis: Nineteenth Century Science or Twentieth Century Snake Oil*, 27 COLUM. HUM. RTS. L. REV. 227, 229, 291 nn.3-4 (1996) (discussing Thompson v. State, 539 A.2d 1052, 1059 (Del. 1988), in which the Delaware Supreme Court held microscopic hair comparisons insufficient for establishing the probable cause necessary for an arrest warrant).

century.[36] As its name implies, it involves the comparison of the microscopic attributes of hairs found at a crime scene with the hairs of a suspect.[37] For cases involving largely circumstantial evidence, microscopy often can provide "decisive corroborative evidence" as the one physical link between the defendant and the victim or crime scene.[38]

In theory, the investigative power of microscopy works similarly to that of mtDNA. If the compared hairs are clearly different—for example, a blond, curly hair versus a straight, black hair—common sense suggests that the potential suspect should be excluded. In contrast, if the compared hairs share many characteristics, then the suspect cannot be excluded and, indeed, the evidence casts additional suspicion on him.

In practice, however, microscopy is a poor substitute for mtDNA, and it has been much maligned for its subjectivity and high error rates.[39] Unlike mtDNA analysis, in which specific base-pair sequences are compared, microscopic hair analysis lacks objective criteria for determining whether two hairs are "consistent." Determining whether or not hairs are consistent is therefore more art than science. The subjectivity inherent in microscopic comparisons leaves the technique open to

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[36] BARRY SCHECK ET AL., ACTUAL INNOCENCE: WHEN JUSTICE GOES WRONG AND HOW TO MAKE IT RIGHT 208 (New American Library 2003) (2000).

[37] *See* Smith & Goodman, *supra* note 35, at 229 & n.22 (describing the microscopy process and citing more substantial discussions of the technique).

[38] Edward J. Imwinkelried, *Forensic Hair Analysis: The Case Against the Underemployment of Scientific Evidence*, 39 WASH. & LEE L. REV. 41, 42–43 (1982).

[39] Williamson v. Reynolds, 904 F. Supp. 1529, 1555 (E.D. Okla. 1995); Imwinkelried, *supra* note 38, at 43–44; *see also* John I. Thornton & Joseph L. Peterson, *The General Assumptions and Rationale of Forensic Identification*, *in* 3 MODERN SCIENTIFIC EVIDENCE: THE LAW AND SCIENCE OF EXPERT TESTIMONY § 24-9.2.3 (David L. Faigman et al., eds., 2d ed. 2002) (suggesting that while microscopy is useful for excluding a suspect, "[i]n an inclusionary mode . . . hair is a miserable form of evidence"); Craig M. Cooley, *Reforming the Forensic Science Community to Avert the Ultimate Injustice*, 15 STAN. L. & POL'Y REV. 101, 158–60 app. A (forthcoming 2004) (cataloging wrongful capital convictions involving microscopic hair analysis).

inconsistencies among examiners and problems such as expectation bias.[40]

The few studies[41] on the reliability of microscopic hair analysis have shown it to have extremely high error rates, perhaps in part because of this subjectivity.[42] A proficiency testing program in the 1970s reported 54% and 67% error rates, which are (remarkably) worse than chance.[43] A recent 2002 study showed that in nine instances out of eighty in which hair was found consistent via microscopy, further mtDNA analysis excluded the suspect.[44]

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[40] Expectation bias is created when hair examiners are only given one suspect's hair to compare. The suggestiveness of the procedure, which singles out the comparison hair as suspicious, pushes examiners toward finding consistencies. *See* Larry Miller, *Procedural Bias in Forensic Science Examinations of Human Hair*, 11 L. & HUM. BEHAV. 157 (1987) (showing that forensic students had a 30.4% error rate when comparing hair, but also noting that the error rate fell to 3.8% when a "lineup" procedure was used instead), *cited in Williamson*, 904 F. Supp. at 1557 (noting the use of the conventional, error-prone procedure in 1995).

[41] *Williamson*, 904 F. Supp. at 1556 (observing the "scarcity of scientific studies regarding the reliability of hair comparison testing").

[42] The two studies showing microscopy to have reasonable reliability, performed by Canadian researchers in the 1970s, showed error rates of 1 in 4500 for scalp hair and 1 in 800 for pubic hair. B.D. Gaudette & E.S. Keeping, *An Attempt at Determining Probabilities in Human Scalp Hair Comparison*, 19 J. FORENSIC SCI. 599, 604-5 (1974) (scalp hair); B.D. Gaudette, *Probabilities and Human Pubic Hair Comparison*, 21 J. FORENSIC SCI. 514, 516-17 (1976) (pubic hair); *see also* Smith & Goodman, *supra* note 35, at 237–40 (discussing the Gaudette conclusions in greater detail). The Gaudette studies were harshly criticized for methodological problems, *see Williamson*, 904 F. Supp. at 1556–57 (discussing "experimental bias"); Smith & Goodman, *supra* note 35, at 242–43 (noting the lack of "double-blind" procedures), and, consequently, were not widely embraced by the forensic community, Thornton & Peterson, *supra* note 39, at § 24-9.2.3 (noting that the Gaudette probability model has "received a cool reception from the forensic science community").

[43] Imwinkelried, *supra* note 38, at 44.

[44] Max M. Houck & Bruce Budowle, *Correlation of Microscopic and Mitochondrial DNA Hair Comparisons*, 47 J. FORENSIC SCI. 1, 3 (2002). Houck and Budowle emphasize that the nine cases should not be construed as false positives, arguing that they merely show the limits of the forensic technique. *Id.* This interpretation seems overly generous. While microscopic hair analysis never purports to establish identity definitively, juries use its conclusions to

Microscopic hair analysis has one other serious drawback. For one reason or another, whether because of microscopy's subjective nature or because of a lack of interest in compiling a database, well-accepted statistics do not exist on the distribution of various types of hair in the population. As a result, experts confine themselves to vague terms such as "consistent" or "similar."[45] While this lack of population statistics is less significant in cases in which the opportunity for committing the crime is limited to only a few individuals (because their hairs can all be compared), it presents troubling issues when a wide pool of potential perpetrators exists. In these latter cases, factfinders receive no guidance as to what weight to give a finding of "consistent."[46] Unlike with observable traits such as hair color, factfinders have no innate sense of the rarity or commonality of the trait in the population.

Concededly, population statistics for mtDNA are currently limited. However, as mentioned earlier, the mtDNA database is rapidly expanding. As the sample size grows, increasingly reliable statistics on the distribution of various mtDNA sequences will become available.[47]

B. mtDNA as the "Better Science"

Theoretically, mitochondrial DNA is almost always available as an alternative to microscopic hair analysis because both techniques focus on the shaft of a recovered hair. Indeed, a recent study suggests that mtDNA is actually a more powerful forensic tool because it is able to make comparisons even when

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assess whether the defendant's involvement is more or less probable. For those nine cases, hair analysis pointed in the wrong direction.

[45] Williamson v. Reynolds, 904 F. Supp. 1529, 1554 (E.D. Okla. 1995) (describing a microscopy expert's testimony, which used terms such as "consistent" and "could have the same source"); Imwinkelried, *supra* note 38, at 43 (noting growing criticism about the vague terms used by hair analysts).

[46] Berger, *supra* note 14, at 1131 (arguing that microscopy cannot be compared to blood-typing because blood types have accepted distributions, whereas microscopy does not).

[47] *See supra* note 27.

microscopy's results are inconclusive.[48] Given this virtually perfect overlap in scope and mtDNA's advantages of greater objectivity, lower error rates, and established population statistics, one suspects that mtDNA will eventually supplant microscopy as the hair analysis tool of choice.[49] For example, the FBI claims that microscopy is now used only in conjunction with mtDNA,[50] with microscopy perhaps serving as an initial filter before more expensive mtDNA techniques are used.

Unfortunately, however, no such complete shift has yet occurred,[51] so the question becomes: what should be done in the interim?

1. Daubert

Even before the use of mtDNA for criminal identification, some courts, most notably the Eastern District of Oklahoma in *Williamson v. Reynolds*,[52] subjected microscopic hair analysis to a searching reliability inquiry under *Daubert*.[53] Later courts, however, appear not to have taken up the cudgel.[54] This result is

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[48] Houck & Budowle, *supra* note 44, at 2 (asserting that mtDNA can achieve definitive results in many cases in which microscopy is inconclusive).

[49] Richard D. Friedman, *Squeezing Daubert Out of the Picture*, 33 SETON HALL L. REV. 1047, 1057–58 (2003) (suggesting that microscopy may be "waning" because mtDNA is thought to be more accurate and because both techniques test the same physical evidence); Berger, *supra* note 14, at 1134–35 (summarizing the advantages of mtDNA and questioning the continued use of microscopy in light of mtDNA).

[50] Beecher-Monas, *supra* note 8, at 1649.

[51] Friedman, *supra* note 49, at 1058 (acknowledging that both mtDNA and microscopy are still in use).

[52] 904 F. Supp. 1529 (E.D. Okla. 1995).

[53] *Id.* at 1558 (excluding microscopic hair analysis as unreliable).

[54] *E.g.*, Johnson v. Commonwealth, 12 S.W.3d 258, 262 (Ky. 1999) (holding microscopy admissible and taking judicial notice of its reliability); Bolin v. State, 960 P.2d 784, 799 (Nev. 1998) (holding that the trial court's admission of microscopy was not "manifestly wrong"); *see also* Paul C. Giannelli, *Scientific Evidence in Civil and Criminal Cases*, 33 ARIZ. ST. L.J. 103, 114 (2001) ("Unfortunately, later cases—even in *Daubert* jurisdictions—have not continued the type of scrutiny [concerning microscopic hair analysis] displayed by the district court in *Williamson*.").

easily explained: with no readily available alternatives, courts were loath to exclude valuable hair evidence altogether.[55] Having some (albeit somewhat unreliable) hair evidence was preferable to having no such physical evidence at all.[56]

Today, with mtDNA in its ascendancy, excluding microscopy under *Daubert* might seem appealing, but *Daubert* is rather ill-fitted to the task. *Daubert*, with its focus on the reliability of methods, is technically an absolute standard, so its operation should not depend on the existence of other forms of evidence.[57] Furthermore, it would be difficult to argue that microscopy is entirely unreliable. Microscopic hair comparison is not charlatanism that lacks any basis in reality. Hair indeed varies from person to person, and the hairs on a single person share similar characteristics. The problem with microscopy is that it is suboptimal. Just because mtDNA is better does not make mtDNA true science and microscopy snake oil.

2. A "Best Science" Rule

Courts interested in nudging forensic analysis away from microscopy and toward mtDNA might wish to impose something along the lines of a "best science" rule, an approach that would be preferable to *Daubert*. Because mtDNA covers the same physical evidence as and is more reliable than microscopy, courts could proclaim mtDNA as the only admissible form of hair-related evidence. Exceptions could be made only when there was a specific finding that microscopy was particularly useful or necessary in a given case.

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[55] *See* Friedman, *supra* note 49, at 1059, 1064 (suggesting that hair analysis is extremely useful evidence, so even if it is somewhat unreliable, there is no reason to keep it from the jury).

[56] Imwinkelried, *supra* note 38, at 65 (arguing that the outright exclusion of scientific evidence may not be desirable because it would create greater dependence on traditional forms of evidence, such as eyewitness testimony, which may be even more unreliable).

[57] United States v. Coleman, 202 F. Supp. 2d 962, 968 (E.D. Mo. 2002) (suggesting that *Daubert* only analyzes the logic of the evidence, not the weight).

Such a rule seems controversial, or perhaps even radical, at first.[58] Courts and the rules of evidence are typically not in the business of requiring that litigants produce the "best evidence" available.[59] As Professor Richard Friedman notes, during a trial, there is "no necessity that any single item of evidence be particularly reliable, or even very powerful."[60] As a general matter, litigants are free to choose the evidence they wish to present.

However, a "best science" rule—or as some commentators have suggested in the tort context, a "better evidence principle"[61]—should be neither controversial nor radical. As a policy matter, the goal of promoting better evidence is well established in many evidentiary doctrines.[62] As a doctrinal matter, fashioning a "best science" rule would practically require only a slightly creative, but well-rooted application of the Rule 403 probative-versus-prejudice standard. The risk of unfair prejudice with microscopy, as with any forensic technique, is that jurors will be unable to detect inaccuracies or improper procedures, and that jurors may give undue weight to the conclusions. The probative value of microscopy, however, is more complicated. In the past,

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[58] For an informative exchange regarding the use of a "Best Evidence Rule" in the scientific evidence context, see Edward J. Imwinkelried, *Should the Courts Incorporate a Best Evidence Rule into the Standard Determining the Admissibility of Scientific Testimony?: Enough Is Enough Even When It Is Not the Best*, 50 CASE W. RES. L. REV. 19 (1999) and David L. Faigman et al., *How Good Is Good Enough?: Expert Evidence Under Daubert and Kumho*, 50 CASE W. RES. L. REV. 645 (2000).

[59] As often taught in Evidence class, the so-called "Best Evidence Rule" is extremely limited in scope and focuses only on original (as opposed to copies of) documents when the proponent is seeking to prove their contents. *See* FED. R. EVID. 1002.

[60] Friedman, *supra* note 49, at 1057.

[61] *See* Faigman et al., *supra* note 58, at 657-63 (discussing the contours of a "better evidence principle" that would require more reliable techniques over time as technology improves).

[62] *See* Richard D. Friedman, *Minimizing the Jury Over-Valuation Concern*, 2003 MICH. ST. L. REV. 967, 974 (suggesting that excluding some (less desirable) forms of evidence may encourage "the presentation of better evidence" in the long run). A thorough and insightful discussion of the best evidence principle is offered in Dale A. Nance, *The Best Evidence Principle*, 73 IOWA L. REV. 227 (1988).

prior to the availability of mtDNA, microscopy had significant probative value. Microscopic hair analysis was essentially the only technique that could take advantage of hair evidence left on the victim or at the crime scene. Exclusion of this evidence would leave jurors with an incomplete picture. But as mtDNA becomes cheaper and more widely available,[63] the discounted probative value of microscopy becomes vanishingly small.[64] For most cases, microscopy adds nothing to the information that an mtDNA analysis already provides.[65] This change in the probative value of microscopy seems sufficient to render it inadmissible on Rule 403 grounds, while simultaneously explaining why microscopy was admissible in the past.

3. Admissibility Versus Weight

Why should courts become involved in the relative merits of different forms of forensic evidence? Ordinarily, sketchy evidence is punished through cross-examination. The way to attack microscopy's unreliability thus could be through the normal trial process, not through exclusion. Indeed, long before mtDNA

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[63] *See* Scanlon, *supra* note 17, at 8B (describing a new mtDNA-based test that promises to reduce mtDNA testing from $4,000 per sample to $100).

[64] See Old Chief v. United States, 519 U.S. 172, 182-84 (1997) (holding that the calculation of probative value may involve comparing evidentiary alternatives). While the concept of discounted probative value is well established, FED. R. EVID. 403 advisory committee's note ("The availability of other means of proof may also be an appropriate factor."), its use in the mtDNA context could arguably require an extension of current doctrine, since the "availability" of mtDNA evidence as an alternative to microscopy may require additional testing in a given case.

[65] Naturally, in those cases in which microscopy offers uniquely probative information or mtDNA is for some reason inconclusive, these special circumstances could be accounted for in the 403 balancing. *Cf.* Berger, *supra* note 14, at 1134 (noting that because hair examiners have some proficiency, there may be some contexts in which microscopy should be allowed).

The current problem is that such an inquiry is rarely made. *See* Imwinkelried, *supra* note 38, at 61 (complaining that "[r]epeatedly, courts have permitted the prosecution analyst to express an opinion based on conventional microscopy without demanding any explanation for the analyst's failure to use more specific, sophisticated techniques").

analysis even existed, Professor Edward Imwinkelried argued that defense attorneys should complain to juries that prosecutors were not using newer and more sophisticated methods of hair analysis.[66]

Good reasons exist for why courts should treat forensic and other scientific evidence more carefully.[67] While we may reasonably expect the average defense attorney to have the tools necessary to attack a lay witness's credibility or perceptive powers, we cannot necessarily assume that counsel will be familiar with the weaknesses of each specialized forensic tool. Even if defense attorneys were adequately well versed, their cross-examination would be a feeble parry against the forensic expert, whose qualifications and reputation in popular culture lend him an aura of infallibility. A more effective rejoinder for the defense would be to introduce an opposing expert but, as we all know, experts can be prohibitively expensive and are often unavailable to indigent defendants.[68] While the Supreme Court has constitutionally required court-appointed experts in certain limited contexts,[69] experts remain elusive for defendants.[70]

Even with a science-oriented defense attorney and a high-priced mtDNA expert, the damage from the prosecution's

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[66] Imwinkelried, *supra* note 38, at 45, 58–59; *id.* at 64 (suggesting that reasonable doubt might be created if defense counsel "called the jury's attention to the fact that the prosecution neglected to use more reliable and sophisticated techniques"). For articles on more advanced, non-mtDNA-based hair analysis techniques, see Smith & Goodman, *supra* note 35, at 228 n.2, and Imwinkelried, *supra* note 38, at 45–58.

[67] *But see* Friedman, *supra* note 49, at 1064–65 (noting that judicial comment may be more appropriate than exclusion as a safeguard against unreliable scientific evidence).

[68] Giannelli, *supra* note 54, at 111 (citing a 1990 study showing that judges often denied requests for experts); *see also* NAT'L RESEARCH COUNCIL, DNA TECHNOLOGY IN FORENSIC SCIENCE 147 (1992) ("When the prosecutor proposes to use DNA typing evidence or when it has been used in the investigation of the case, an expert should be routinely available to the defendant.").

[69] *See* Ake v. Oklahoma, 470 U.S. 68, 83–84 (1985) (establishing a constitutional right to a psychiatric expert in cases in which sanity and future dangerousness are in issue).

[70] Giannelli, *supra* note 54, at 110 (criticizing the disparity of resources for expert testimony in criminal cases and noting that FBI forensic services are free for prosecutors).

microscopy expert may be already done. Jurors will be left to choose between warring experts—one proclaiming the reliability of microscopy and the other deriding it—an unenviable task often noted by courts and commentators alike. Excluding forms of forensic evidence that are not the "best science" available would preclude such battles of experts.

IV. PRIVACY AND MTDNA DATABANKS

Beyond the evidentiary issues outlined above, mitochondrial DNA also raises an interesting privacy issue in the area of databanking. The FBI and all fifty states currently maintain DNA databases.[71] These databases contain nuclear DNA profiles from convicts, crime scenes, and unidentified bodies as well as DNA profiles that are contributed voluntarily by relatives of missing persons.[72] Police use these databases to find suspects, identify bodies, and convict defendants, and the databases have quickly proven to be invaluable tools for law enforcement.

Congress, however, has sought to protect privacy values by limiting just whose DNA the government can databank. Under federal law, the FBI is required to expunge a person's DNA if his conviction is overturned, and states are required to behave similarly if they wish to have access to the national database.[73] These provisions express a policy determination that, while the police may collect (and presumably databank) DNA from arrestees and those for whom they have probable cause,[74] only the DNA of convicts and voluntary contributors should be kept permanently.

The success of the nuclear DNA databank has naturally led to

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[71] Robin C. Miller, Annotation, *Validity, Construction, and Operation of State DNA Database Statutes*, 76 A.L.R.5th 239, §2[b] (2000) (noting that all fifty states have created DNA databases); Michelle Hibbert, *DNA Databanks: Law Enforcement's Greatest Surveillance Tool?*, 34 WAKE FOREST L. REV. 767, 783 (1999) (reporting that states databank the DNA of sex offenders).

[72] *See generally* 42 U.S.C. § 14132(a) (2004) (tasking the FBI with establishing a database of DNA from convicts, crime scenes, and unidentified bodies, as well as DNA voluntarily contributed by relatives of missing persons).

[73] *Id.* § 14132(d)(1) & (2) (2004).

[74] *See* Imwinkelried & Kaye, *supra* note 13, at 418–22 (discussing the various standards used to assess the validity of DNA sampling by the police).

the development of an mtDNA databank, which would be used for similar purposes.[75] However, because mtDNA has maternal linkage, banking mtDNA has privacy implications that extend beyond that particular convict.[76] If officials run an mtDNA search on material found at a crime scene and find a "hit" in the database, that offender and all of his maternal relatives would become instant suspects.[77] As such, the privacy interests of those maternal relatives will be difficult to protect. Any attempt to limit the use of the "hit" to the person banked would be tantamount to unringing a bell.[78]

Interestingly, the family-member privacy problem does not seem exclusive to mtDNA databanks. Nuclear DNA is shared, albeit not perfectly, between parents, children, and relatives. Consequently, blood relatives share significant portions of their DNA profiles, therefore raising similar privacy problems when officials exploit near-matches of nDNA database searches.[79]

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[75] Fisher, *supra* note 8, at 3-4 (discussing the MitoSearch and CODIS^{mt} software systems for searching the national mtDNA database).

[76] Hibbert, *supra* note 71, at 783 (arguing that mtDNA databanking "has implications not only for the banked offender, but also for his or her non-banked relatives").

[77] Eric T. Juengst, *Symposium: I-DNA-Fication, Personal Privacy, and Social Justice*, 75 CHI.-KENT L. REV. 61, 80 (1999) (suggesting that the "appearance of [maternal] family members in an arrestee database might even make them immediate suspects for investigation").

[78] *Id.* at 81 (recommending that banked DNA should only be used against the person banked).

[79] An example of this problem can be found in the facts of Flowers v. State, 654 N.E.2d 1124 (Ind. 1995), in which the police initially suspected the defendant's brother and obtained a warrant for his blood. *Id.* at 1124. When nDNA tests showed that the brother was not involved, but that a close relative was, police obtained a warrant for the defendant's blood and found a match. *Id.* The Indiana Supreme Court ultimately reversed the defendant's conviction on other grounds. *Id.* at 1125.

CONCLUSION

Mitochondrial DNA promises to be a powerful new forensic tool for identifying offenders and obtaining more accurate convictions. Its chief benefit will likely be as a more reliable and precise replacement for traditional microscopic hair analysis, which has been widely criticized as being too subjective, prone to error, and of unknown probative value. As a result, police and forensic investigators will be able to continue using crime-scene hair—often important physical evidence—but with a more scientifically rigorous technique.

To ensure mtDNA's proper use, however, judges will need to remain vigilant. As with any scientific evidence, the court's role as gatekeeper requires that it determine not only that mtDNA analysis is based on reliable principles and procedures, but also that those procedures have been followed. In addition, jurors must understand that mtDNA lacks the resolving power of nuclear DNA. Mitochondrial DNA profiles are not unique, but are instead distributed in small numbers throughout the population. Moreover, maternal relatives all share the same mtDNA profile, making mtDNA far less probative in cases involving multiple suspects from the same family.

Finally, due to its maternal links, mtDNA will raise interesting privacy concerns as mtDNA databases grow in size. Using an mtDNA hit as grounds for suspicion against all maternal relatives of a banked person implicates some of the privacy interests Congress sought to protect when it placed restrictions on the national DNA database. How courts will wrestle with that seemingly intractable problem remains an open question.