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ARTICLES

FORENSIC HAIR ANALYSIS: THE CASE AGAINST THE UNDEREMPLOYMENT OF SCIENTIFIC EVIDENCE

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"A little learning is a dangerous thing;
Drink deep, or taste not the Pierian spring;
There shallow draughts intoxicate the brain,
And drinking largely sobers us again."
—Alexander Pope, *Essay on Criticism*

This year marks the one hundredth anniversary of the use of scientific hair evidence in American prosecutions. A century ago in *Knoll v. State*,[1] the Wisconsin Supreme Court first considered the use of forensic hair analysis in a criminal case.[2] The *Knoll* opinion has a suprisingly modern ring to it. In *Knoll*, as in most contemporary cases,[3] the analyst utilized a microscope to compare the hair samples.[4] Further, like a modern microscopist,[5] the analyst in *Knoll* testified that his comparison led him to the conclusion that the hair samples had a common source.[6] When *Knoll* was decided, scientific hair analysis was a novelty.[7] In the one hundred years since *Knoll*, all the key participants in the American criminal justice system have become familiar with scientific hair evidence.

Hair evidence is of obvious interest to the police laboratory criminalist. Hair is one of the most common materials subjected to crime

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[1] 55 Wis. 249, 12 N.W. 369 (1882).

[2] *Id.* The first case involving hair evidence appears to have been Lindsay v. State, 63 N.Y. 143 (1875). However, in *Lindsay*, the evidence was a lay identification based in part on hair rather than scientific examination of a hair sample. *Id.* at 145, 152.

[3] *See, e.g.*, People v. Allweiss, 48 N.Y.2d 40, 49-50, 396 N.E.2d 735, 740 (1979).

[4] 55 Wis. at 252-53, 12 N.W. at 370.

[5] *See, e.g.*, State v. Batten, 17 Wash. App. 428, 437-38, 563 P.2d 1287, 1292-93 (1977).

[6] 55 Wis. at 252-53, 12 N.W. at 370.

[7] Two years after *Knoll*, two forensic scientists, Waldeyer and Grimm, published their pioneering text on hair analysis. W. WALDEYER & J. GRIMM, ATLAS DER MENSCHICHEN UND TIERISCHEN HAARE, SOWIE DER AHNLICHEN FASERGEBILDE (1884). Shortly after the turn of the century, Lambert and Balthazard published their test on hair classification. M. LAMBERT & V. BALTHAZARD, LE POIL DE L'HOMME ET DES ANIMAUX (1910).

laboratory examination.[8] The analyst sometimes searches the surface of a hair sample for a fluid such as semen.[9] More often, however, the analyst focuses on the hair sample itself. Hair can be recovered as individual shafts or as a component of a heterogeneous mixture such as debris. The samples may be found on surfaces of topsoil, clothing, vehicles, weapons, and skin. The analyst uses a wide array of sophisticated instruments, including the comparison microscope,[10] the scanning electron microscope (SEM),[11] and neutron activation analysis (NAA),[12] to examine the hair samples recovered from these surfaces.

The laboratory analyst submits his or her findings to another element of the criminal justice system, a police agency. Hair evidence has become a valuable investigative tool for the police.[13] The evidence is very important because of the transference or exchange phenomenon.[14] Simply stated, the phenomenon is that when two surfaces such as skin and clothing come into contact, there will be an exchange or transfer between the two.[15] Because of the exchange phenomenon, hair samples are often critical clues to identifying the perpetrator of a broad range of crimes, including rape, burglary, assault, and vehicular homicide.[16]

Just as the laboratory analyst relays the results of the hair examination to the police, the police in turn submit the laboratory findings to the prosecutor when they believe that they have identified the perpetrator. The use of forensic hair evidence in the courtroom has increased dramatically in the century since *Knoll*. There were only a handful of prosecutions involving hair analysis in the nineteenth century.[17] There probably have been as many hair cases in each year during the 1970's as there were during the entire prior century.[18] Hair evidence is now used

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[8] *Don't Miss A Hair*, F.B.I. Law Enforcement Bull. (Reprint), Dec. 1968, at 1 [hereinafter cited as *Don't Miss A Hair*].

[9] Evans & Beyer, *The Importance of Examining Skin and Hair for Semen in Sexual Assault Cases*, 26 J. FOR. SCI. 605 (1981).

[10] The comparison microscope is actually two separate but identical microscopes. The first specimen is mounted on one microscope while the second specimen is mounted on the second microscope. The specimens are then observed side by side as if they were in the same field.

[11] *See* text accompanying notes 167-74 *infra*.

[12] *See* text accompanying notes 92-94 and 192-97 *infra*.

[13] *See, e.g., Hairs and Fibers Prove Valuable in Hit-Run Cases*, F.B.I. Law Enforcement Bull. (Reprint), Jan. 1961.

[14] Thomas v. State, 374 So. 2d 508, 514 (Fla. 1979), *cert. denied*, 445 U.S. 972 (1980).

[15] *Id.*

[16] *Don't Miss A Hair*, *supra* note 8, at 1.

[17] Watt v. People, 126 Ill. 9, 18 N.E. 340 (1888); Lindsay v. State, 63 N.Y. 143 (1875); Gray v. Commonwealth, 101 Pa. 380, 47 Am. Rep. 733 (1882); Kugadt v. State, 38 Tex. Crim. 681, 44 S.W. 989 (1898); State v. Smith, 9 Wash. 341, 37 P. 491 (1894); Knoll v. State, 55 Wis. 249, 12 N.W. 369 (1882). Only *Knoll* involved scientific examination of a hair sample.

[18] In 1977, for example, eight cases involving hair evidence were decided. *See* United States v. Cyphers, 553 F.2d 1064 (7th Cir.), *cert. denied*, 434 U.S. 843 (1977); State v. Blazak, 114 Ariz. 119, 560 P.2d 54 (1977); People v. Estep, 39 Colo. App. 132, 566 P.2d 706 (1977),

extensively and serves as "a very vital link in the chain of evidence."[19] Especially when the prosecution case rests primarily on circumstantial evidence, hair samples can be decisive corroborative evidence.[20] The use of hair and fiber evidence in the recent *Bundy* case[21] and the highly publicized *Williams* prosecution in Atlanta[22] underscores how frequently criminal attorneys encounter this type of evidence.[23]

Although hair evidence is now widely used, several commentators have recently questioned the value of hair evidence. These critics point out how little hair analysis seems to have progressed in the past century. The *Knoll* case reads as a contemporary opinion precisely because police laboratories still rely heavily on conventional microscopes[24] and their analysts continue to couch their testimony in the conclusory language that the samples are "similar"[25] and "could have"[26] come from the "same source."[27] Given the startling advances in other scientific fields,[28] this seeming lack of progress is alarming.

The critics of hair evidence have translated their doubts about the value of hair evidence into two specific criticisms. First, they charge that hair analysis is too subjective to be truly scientific.[29] The critics argue that so long as the state of the art permits only the vague conclusion that hair samples are similar, it is impossible to make "an objective assessment of the value of that type of evidence."[30] The subjective

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rev'd, 196 Colo. 3d 340, 583 P.2d 927, *cert. denied*, 440 U.S. 983 (1978); People v. Watkins, 78 Mich. App. 89, 259 N.W.2d 381 (1977); Commonwealth v. Long, 470 Pa. 204, 368 A.2d 265 (1977); State v. Earley, 118 R.I. 205, 373 A.2d 162 (1977); State v. Vargus, 118 R.I. 113, 373 A.2d 150 (1977); State v. Batten, 17 Wash. App. 428, 563 P.2d 1287 (1977).

In 1979, six cases involving hair evidence were decided. *See* United States v. Brady, 595 F.2d 359 (6th Cir.), *cert. denied*, 444 U.S. 862 (1979); United States v. Massey, 594 F.2d 676 (8th Cir. 1979); People v. DiGiacomo, 71 Ill. App. 3d 56, 388 N.E.2d 1281 (1979); State v. Huckaby, 368 So. 2d 1059 (La. 1979); People v. Allweiss, 48 N.Y.2d 40, 396 N.E.2d 735 (1979); People v. Roff, 67 A.D.2d 805, 413 N.Y.S.2d 43 (1979).

[19] Padilla v. People, 156 Colo. App. 186, 188, 397 P.2d 741, 743 (1964).

[20] *Id.*

[21] *See Fiber Analyst Lynn Henson Helps Unravel the Atlanta Murders*, People, July 27, 1981, at 34.

[22] *See id.*; *Using Fiber Evidence*, The Nat'l L.J., July 6, 1981, at 39.

[23] A national survey recently found that 44% of the judges and attorneys questioned encounter scientific evidence in approximately one third of their cases. *See* National Center for State Courts Report, Aug. 1980.

[24] *See, e.g.*, Skinner v. Commonwealth, 212 Va. 260, 262, 183 S.E.2d 725, 727 (1971).

[25] *See, e.g.*, Acrey v. Commonwealth, 312 Ky. 732, 735, 229 S.W.2d 748, 750 (1950).

[26] *See, e.g.*, State v. Batten, 17 Wash. App. 428, 437, 563 P.2d 1287, 1293 (1977).

[27] *See, e.g.*, State v. Andrews, 86 R.I. 341, 345, 134 A.2d 425, 428, *cert. denied*, 355 U.S. 898 (1957).

[28] *See generally* SCIENTIFIC AND EXPERT EVIDENCE (E. Imwinkelried ed. 1981) [hereinafter cited as Imwinkelried] (detailing the progress in numerous scientific disciplines).

[29] Coleman & Walls, *The Evaluation of Scientific Evidence*, 1974 CRIM. L. REV. 276, 280 [hereinafter cited as Coleman & Walls].

[30] *Id.*

nature of this evidence is most likely to generate a swearing contest between analysts—the so-called "battle of the experts"[31]—that neither a lay judge nor a lay juror is competent to resolve.

Second, the critics emphasize that there is a high incidence of error in hair analysis. In the early 1970's, several studies uncovered a disturbingly high percentage of error in forensic analysis.[32] The Law Enforcement Assistance Administration became so concerned that it sponsored its own Laboratory Proficiency Testing Program.[33] Between 235 and 240 crime laboratories throughout the United States participated in the Program.[34] The committee conducting the Program hired analytical laboratories to make complete examinations of various types of evidence, including hair samples. Armed with the analytical laboratories' findings, the committee sent the evidence samples to the participating crime laboratories. The committee compared the police laboratories' reports with the analytical laboratories' findings.

On the whole, the Program documented a very real possibility of error in the forensic analyses conducted by police laboratories in the United States.[35] Moreover, by a wide margin, the police laboratories' performance on hair analysis was the weakest. Twenty percent of the laboratories failed test #5, paint analysis; but even that figure pales in comparison to the fifty four percent that misanalyzed hair sample C.[36] Again, it is unsettling that thirty percent of the laboratories failed test #9, glass analysis; but that error margin seems minimal compared to the sixty seven percent of the laboratories that misanalyzed hair sample D.[37] On four of the five hair samples analyzed, the majority of the laboratories erred—an accuracy level below chance.[38]

The conclusion that most readily suggests itself is that we should immediately reduce the use of hair evidence—if not ban the evidence altogether. The criticisms seem to lead logically to that conclusion; and in the opinion of this author, the criticisms are well-grounded. However, the thesis of this article is precisely the contrary conclusion: We should rely more extensively on hair evidence than we have in the past. The paradox is that if the grounds for the criticism of hair evidence are prop-

[31] *See* Myers, *"The Battle of the Experts": a New Approach to an Old Problem in Medical Testimony*, 44 NEB. L. REV. 539, 539 (1965).

[32] *See* Dinovo & Gottschalk, *Results of a Nine-Laboratory Survey of Forensic Toxicology Proficiency*, 22 CLIN. CHEM. 843, 843-46 (1976); Center for Disease Control, Public Health Service, Atlanta, Ga., Report on Toxic Volatiles Survey #1, Report on Toxicology Survey #2, Report on Toxicology Survey #3 (1971-72).

[33] *See* Imwinkelried, *The Constitutionality of Introducing Evaluative Laboratory Reports Against Criminal Defendants*, 30 HASTINGS L.J. 621, 636 (1979).

[34] *Id.*

[35] *Id.*

[36] Imwinkelried, *Introduction*, in Imwinkelried, *supra* note 28, at 4.

[37] *Id.*

[38] *Id.*

erly understood, we should use more forensic hair evidence to improve the reliability of fact-finding in criminal cases.

The first section of this article surveys the state of the art of forensic hair analysis. The section lists the factual determinations a hair analyst can make and catalogues the instruments the analyst uses to make those determinations. The second section of the article demonstrates that both prosecutors and defense counsel "underemploy" hair evidence. Prosecutors do so by relying on less reliable analytic techniques. Defense counsel are equally guilty; they routinely fail to call the jury's attention to the more reliable analytic techniques that the prosecution neglects to use. The third and final section reaches the merits of the criticisms of forensic hair evidence. The section argues that, for both the prosecution and the defense, more extensive use of hair evidence would result in better trial advocacy and an increased accuracy of fact-finding in criminal cases.

I. The State of the Art of Hair Analysis

If one read only the appellate court opinions dealing with hair evidence, one would quickly leap to the conclusion that the science of hair analysis is still in the same primitive state that it was in when the Wisconsin Supreme Court decided *Knoll*.[39] However, even a cursory review of the scientific journals will dispel that erroneous conclusion. In the current state of the art, an analyst can employ a myriad of techniques to reach a large number of findings about a hair sample.

A. *Determining Whether the Sample Is Hair*

The threshold determination for the analyst is whether a sample is a hair at all, rather than vegetable or synthetic fiber.[40] The analyst may use chemical, macroscopic, or microscopic techniques to make that finding.

The chemical technique is a test of the hair's ability to burn. Vegetable fibers burn rather easily, emit a smell like burnt wood, and leave a sharply burnt end.[41] In contrast, it is difficult to set hair aflame.[42] Additionally, burning hair creates a smell like burning feathers, and burnt hair usually has a fused or rounded shaft end.[43]

There is also a macroscopic technique for distinguishing hair from fiber. Hairs ordinarily grow singly without branching.[44] Vegetable fibers

[39] *See, e.g.*, text accompanying notes 24-27 *supra*.

[40] A. MOENSSENS & F. INBAU, SCIENTIFIC EVIDENCE IN CRIMINAL CASES 405 (2d ed. 1978) [hereinafter cited as MOENSSENS & INBAU]; 5 AM. JUR. PROOF OF FACTS *Hair* 569, 571 (1960) [hereinafter cited as *Hair*].

[41] *Hair*, *supra* note 40, at 571.

[42] *Id.*

[43] *Id.*

[44] *Id.*

are readily distinguishable because they often grow in tight bunches and exhibit branching.[45] The analyst can detect these characteristics even without the benefit of a microscope.

The microscopic technique is probably the most trustworthy method of determining whether the sample is hair. If the microscopist takes a lengthwise (full-mount or longitudinal) view of a hair strand, the analyst can observe a tip end, a shaft, and a bulb or root end.[46] When the microscopist takes a cross-sectional or transverse view, the analyst will see three concentric rings. The core is the medulla, containing cellular debris and pigment granules of melanin.[47] The middle ring is the cortex, which also includes pigment.[48] The cortex is composed of flat, elongated cells that give the strand its pliability.[49] The outermost layer is the surface cuticle,[50] which consists of overlapping scales.[51] The scales are transparent and point toward the tip end of the hair strand.[52]

B. *Determining Whether the Hair Is Human or Animal*

Using one of several methods, the analyst can also determine whether a hair strand is of human or animal origin. To begin with, the analyst can make several micro-measurements that are helpful in the differentiation.[53] One measurement is the diameter of the hair. The nonhuman primate maximum diameters exceed human averages at both the low and high ends of the range, but there is some overlap between human and nonhuman primate diameters.[54] The analyst may also measure the cross-section area, but again there is overlap, particularly between human hair and that of Old World monkeys.[55] The cuticle scale count (the number of cuticle scales per unit of measure) is yet another indicator, but the analyst cannot discriminate between human and animal hair solely on the basis of scale count.[56] There are other features such as cuticle scale width that are indicative of human origin,[57] but the most sober assessment is that "[t]he metrical features of human head hair are not distinct enough from those of other primates to use micro-measurement as a sole means of hair identification."[58]

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[45] *Id.*
[46] MOENSSENS & INBAU, *supra* note 40, at 405; *Don't Miss A Hair, supra* note 8, at 2.
[47] MOENSSENS & INBAU, *supra* note 40, at 405.
[48] *Id.*
[49] *Id.*
[50] *Id.*
[51] *Don't Miss A Hair, supra* note 8, at 2.
[52] MOENSSENS & INBAU, *supra* note 40, at 405.
[53] Rosen, *Identification of Primate Hair*, 19 J. FOR. SCI. 109, 109 (1974).
[54] *Id.*
[55] *Id.*
[56] *Id.* at 110.
[57] *Id.* at 111.
[58] *Id.* at 112.

In addition to the micro-measurement technique, there are macroscopic and microscopic methods of differentiating human and animal hair. The macroscopic technique involves examining the hair's gross characteristics. Animal hair varies in type; many animals have both heavy guard hair and finer fur hair.[59] Human hair is unitary in type.[60]

As in the case of deciding whether material is hair, the most reliable technique is microscopy. The microscope enables the analyst to detect distinctive characteristics in the cuticle, cortex, and medulla.

Human hair tends to have a narrow central medullary canal.[61] The human medulla is normally fragmented[62] and has no obvious cell pattern.[63] The human medulla approximates one third of the width of the cortex.[64] Animal hair differ in each respect. The hair of lower animals have a broad medulla, display a clear cellular structure, and usually have medullas more than half as broad as the cortical shell.[65]

The human cortex layer contains the majority of the pigment granules while, in other mammals, most pigment is located in the medulla.[66] There are other differences as well. In the human cortex, the pigment granules are packed most densely toward the peripheral areas.[67] There is often a central accumulation of pigment cells in animal hair.[68]

The cuticle or scale shell also aids the microscopist in distinguishing between human and animal hair. The scales of human hair overlap smoothly, but those of other mammalian species often protrude roughly.[69] None of these characteristics is exclusively human, but the cumulative presence of these characteristics makes it almost certain that the hair is human in origin.[70]

Those hair characteristics can be observed with a conventional microscope. By employing SEM,[71] French researchers believe that they have discovered new minute features in the medulla "that absolutely differentiate[s] human hairs from all other animal hairs. . . ."[72]

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[59] *Don't Miss A Hair, supra* note 8, at 2.
[60] *Id.*
[61] *Hair, supra* note 40, at 572.
[62] MOENSSENS & INBAU, *supra* note 40, at 508.
[63] *Hair, supra* note 40, at 572.
[64] *Id.*
[65] *Id.*
[66] MOENSSENS & INBAU, *supra* note 40, at 508.
[67] *Hair, supra* note 40, at 572.
[68] *Id.*
[69] MOENSSENS & INBAU, *supra* note 40, at 508.
[70] *Hair, supra* note 40, at 572.
[71] *See* text accompanying notes 167-74 *infra.*
[72] Clement, Hagege, Pareux, Connet & Gastaldi, *New Concepts About Hair Identification Revealed by Electron Microscope Studies,* 26 J. FOR. SCI. 447, 457 (1981) [hereinafter cited as Clement].

The analyst cannot only distinguish human from animal hair; at another level, the analyst can also determine the animal species. For example, under even the conventional microscope, it is possible to detect differences among horse, deer, antelope, and beef hairs.[73] One text on animal hair identification contains photomicrographs of seventy-six mammalian species and describes the unique diagnostic features of each species.[74] Over the years, the techniques for sectioning hairs have improved,[75] and these improved techniques have resulted in better transverse views of the diagnostic traits of the various animal families.[76]

C. *Determining Whether the Human Source Was Male or Female*

There are a number of techniques for determining the sex of the person who was the source of the human hair strand. The oldest method relies upon the strands' gross characteristics. Male hair is generally larger in diameter, shorter in length, and more wiry in texture.[77] The average diameter of male human hair is 1/350 inch while that of female hair is approximately 1/450 inch.[78] Until the last decade, women routinely manipulated their hair more extensively than men by pinning, curling, brushing, and combing. The manipulation frequently caused the tip ends of female hair to split.[79] Within this decade, however, men have begun to treat their hair more frequently, and consequently the presence of a split end now has much less evidentiary value.[80]

Fortunately, more reliable techniques have emerged for making the sex determination. One technique is the test for the X-chromatin body in the hair root sheath.[81] Roughly sixty percent of the cells of a normal woman will include the chromatin body.[82] The corresponding figure for male cells is two percent.[83] The presence of X-chromatin bodies is a specific test, since the frequencies do not overlap; the smallest reported percentage for a female is higher than the greatest recorded percentage for a male.[84]

There are times when the analyst cannot use the X-chromatin test.

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[73] *Laboratory Solves Variety of Crimes with Animal Hairs*, F.B.I. Law Enforcement Bull. (Reprint), March 1960, at 2.

[74] H. BRUNNER & B. COMAN, THE IDENTIFICATION OF MAMMALIAN HAIR (1974).

[75] *See* Cooper & Kirk, *An Improved Technique for Sectioning Hair*, 44 J. CRIM. L.C. & P.S. 124, 124-27 (1953).

[76] *See id.* at 127.

[77] *Don't Miss A Hair*, *supra* note 8, at 4.

[78] *Id.*

[79] *Id.*

[80] *Id.*

[81] *See* MOENSSENS & INBAU, *supra* note 40, at 410; Nagamori & Takeda, *Sex Determination from Plucked Human Hairs Without Epithelial Root Sheath*, 17 FOR. SCI. INT'L 85, 86 (1981) [hereinafter cited as Nagamori & Takeda].

[82] MOENSSENS & INBAU, *supra* note 40, at 410.

[83] *Id.*

[84] Nagamori & Takeda, *supra* note 81, at 86.

Conducting the test requires hair strands with an intact root sheath.[85] Some crime scenes do not yield strands with their sheath. Hair is likely to lack its sheath, for example, when it has been severed by a weapon.[86] This problem led to the development of another technique for analyzing sheathless hair strands: the Y-chromosome test.[87] The experimental data indicates that when properly stained, the Y-chromosome in the hair cortex nuclei fluoresces.[88] In one experiment, the average frequency for male hairs was 59.4 percent while the figure for female hair was only 5.3 percent.[89] As in the case of the X-chromatin test, the frequencies do not appear to overlap.[90] In another Y-chromosome experiment, there were no false positives.[91]

Finally, NAA[92] aids in distinguishing male from female hair. There are differences in trace element concentrations between male and female hair.[93] One estimate is that the trace element concentration differences will permit the determination of the sex of the source of the hair samples approximately ninety percent of the time.[94] This test is not as conclusive as the X-chromatin or Y-chromosome test, but it is a helpful, confirmatory test.

D. *Determining the Race of the Human Hair Source*

The hair analyst cannot determine race as positively as sex, but the analyst nevertheless can make a relatively confident finding as to the race of the human hair source.[95] The analyst can categorize the hair into one of four groups: Caucasian, Negroid, Mongoloid (including Asiatics and Indians), or mixed.

Caucasian hair has the widest range of color differences.[96] The pigment is evenly distributed.[97] Cross-sections of Caucasian hair are typically oval to round in shape.[98] The hair is usually straight or wavy but not tightly curled.[99]

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[85] Nagamori, *Sex Determination From Plucked Human Hairs Without Epithelial Root Sheath*, 12 FOR. SCI. INT'L 167, 167 (1978).

[86] *Id.*

[87] *Id.*

[88] *Id.*

[89] *Id.* at 169.

[90] *Id.*

[91] Kringsholm, Thomsen & Henningsen, *Fluorescent Y-Chromosomes in Hairs and Blood Stains*, 9 FOR. SCI. 117, 123 (1978).

[92] *See* text accompanying notes 192-97 *infra.*

[93] Comment, *The Evidentiary Uses of Neutron Activation Analysis*, 59 CAL. L. REV. 997, 1054 (1971) [hereinafter cited as *Evidentiary Uses of NAA*].

[94] *Id.*

[95] *Don't Miss A Hair, supra* note 8, at 3; MOENSSENS & INBAU, *supra* note 40, at 409.

[96] *Hair, supra* note 40, at 573.

[97] *Don't Miss A Hair, supra* note 8, at 3.

[98] *Id.*

[99] *Id.*

Negroid hair has dark pigment distributed unevenly.[100] The pigment often clumps along the periphery of the cortex.[101] In a cross-section view, the hair appears flat or oval.[102] The hair is frequently kinky.[103]

Like Negroid hair, Mongoloid hair has dense pigment.[104] However, as is true in the case of Caucasian hair, the pigment of Mongoloid hair is rather evenly distributed.[105] Under a cross-section view, its shaft has a circular or triangular shape.[106] Mongoloid hair tends to be coarse and straight.[107]

If a person is of mixed race, his or her hair will display the characteristics of the ethnic group that predominates in the person's physical appearance.[108] Hence, if the person is of mixed race but had predominantly Negroid features, the person's hair will similarly display Negroid characteristics.

E. *Determining the Region of the Body the Hair Sample Came From*

Microscopy also can enable the analyst to determine the part of the human body that a hair strand came from. Scalp or crown hair tends to be soft and long.[109] Scalp hair ordinarily displays less diameter variation and more even pigment distribution than hair from other regions of the body.[110] Eyebrow, eyelash, and nostril hairs are short, stiff, and thick.[111] They have wide medullas, and they taper very quickly to a fine point.[112] Beard and moustache hairs are the thickest.[113] Beard hair is very curved and coarse.[114] These hairs are irregular in shape and have a triangular cross-section.[115]

Hairs from the chest or back seem immature.[116] They are generally fine, short, and flexible.[117] Hairs from legs and arms are short, fine, and contain little pigment.[118] Pubic and axillary (armpit) hairs are wiry.[119]

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[100] *Id.*
[101] *Hair, supra* note 40, at 573.
[102] *Don't Miss a Hair, supra* note 8, at 3.
[103] *Hair, supra* note 40, at 573.
[104] *Don't Miss a Hair, supra* note 8, at 3.
[105] *Id.*
[106] *Hair, supra* note 40, at 573.
[107] *Don't Miss a Hair, supra* note 8, at 3.
[108] *Id.*
[109] *Hair, supra* note 40, at 574.
[110] MOENSSENS & INBAU, *supra* note 40, at 409.
[111] *Don't Miss a Hair, supra* note 8, at 4; *Hair, supra* note 40, at 574.
[112] *Don't Miss a Hair, supra* note 8, at 4.
[113] *Hair, supra* note 40, at 574.
[114] MOENSSENS & INBAU, *supra* note 40, at 409.
[115] *Hair, supra* note 40, at 574.
[116] MOENSSENS & INBAU, *supra* note 40, at 409.
[117] *Hair, supra* note 40, at 574.
[118] MOENSSENS & INBAU, *supra* note 40, at 409.
[119] *Hair, supra* note 40, at 574.

They have numerous twists[120] and abruptly change their diameters.[121]

F. *Determining Whether the Human Hair Source was an Adult or Child*

There are two techniques for determining the age of the human hair source. Unfortunately, neither technique is precise.

The first method is microscopy.[122] Children's hair are finer, thinner, and less well-developed.[123] However, the state of the art does not enable the analyst to be more specific. The analyst cannot even rely on graying or balding as the basis for a finding that the person was elderly rather than middle-aged, since both graying and balding can occur prematurely.[124] One clue is the variety in the size, shape, and pigmentation of a person's scalp hair; the older the person, the greater the variety.[125]

The other technique is a chemical test. The test involves dissolving the hair in a solution of caustic potash.[126] The faster the roots dissolve, the younger the human hair source.[127] The speed of dissolution is relative and varies, and for that reason the caustic potash test does not permit an exact age estimate.

G. *Determining Whether the Hair Was Natural or Dyed*

Natural hair can be distinguished from dyed hair microscopically.[128] Dyed hair has a duller appearance, and the inner margin of its cuticle is obscured.[129] Moreover, since hair grows at the rate of approximately 1/2 inch per month,[130] there often will be a sharp contrast between the previously dyed portion of the hair strand and the new natural growth.[131]

H. *Determining Whether the Hair Fell Out or Was Pulled*

If hair falls out naturally, the strand will have its root end.[132] The presence of a root is powerful evidence that the hair fell out due to natural causes such as disease.[133] Further, such a hair will have a clean appearance.[134] The appearance of a pulled hair differs markedly. The

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120 MOENSSENS & INBAU, *supra* note 40, at 409.
121 *Hair, supra* note 40, at 574.
122 *Don't Miss a Hair, supra* note 8, at 3-4.
123 *Hair, supra* note 40, at 575.
124 *Id.*; *Don't Miss a Hair, supra* note 8, at 3-4.
125 *Hair, supra* note 40, at 575-76.
126 *Id.* at 575.
127 *Id.*
128 *Don't Miss a Hair, supra* note 8, at 5.
129 MOENSSENS & INBAU, *supra* note 40, at 410.
130 *Don't Miss a Hair, supra* note 8, at 5.
131 MOENSSENS & INBAU, *supra* note 40, at 410.
132 *Don't Miss a Hair, supra* note 8, at 4.
133 *Id.*
134 *Id.*

pulled strand will seem mutilated, and the bulb may have a portion of the sheath clinging to it.[135]

I. *Determining Whether the Human Hair Source Was Poisoned*

If a person was killed by arsenic poisioning, there will be an arsenic residue in the hair.[136] Proof of the arsenic residue can be important evidence of the homicidal character of the death.

J. *Determining Whether the Hair Was Cut or Crushed*

The analyst can also make a finding as to whether the hair was cut or crushed. If the hair was cut, the cortical shells of the shaft will display a clean, smooth slice.[137] However, if the assailant used a blunt instrument, the cortical cells will have a jagged, crushed, or rough appearance.[138]

K. *Determining the Blood Grouping of the Human Hair Source*

During the past decade, the general field of serology or blood analysis progressed as rapidly as any scientific discipline.[139] The same holds true for the specific application of serology to hair analysis. In certain circumstances, the analyst can determine the ABO blood grouping of the human hair source.[140] Japanese researchers have perfected techniques for detecting enzyme types including ES-D, PGM_1, PGM_2, and PGM_3 from hair samples.[141] Even more recently, researchers have begun typing the proteins or keratins in the cortex of human hair.[142]

These developments are very significant. In the past, relying on microscopic examination, the hair analyst could express only the vague opinion that hair samples are "similar" or that their characteristics are "consistent" with the hypothesis that they originated from a common source.[143] The analyst could not quantify the opinion with any precision. The importance of the serological breakthroughs is that data exists on the population frequencies with which the various blood, enzyme, and

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[135] *Id.*

[136] *Hair, supra* note 40, at 576.

[137] *Don't Miss a Hair, supra* note 8, at 4.

[138] *Id.*

[139] *See* Wraxall, *Forensic Serology,* in Imwinkelried, *supra* note 28, at 897.

[140] *See generally* Lincoln & Dodd, *Mixed Agglutination as a Method for the Determination of A, B, and H Blood Groups of Hair,* 8 MED., SCI. & L. 38 (1968).

[141] *See generally* Yoshida, Abe & Nakamura, *Studies on the Frequencies of* PGM_1, PGM_3, *and Es-D Types From Hair Roots in Japanese Subjects and the Determination of These Types From Old Hair Roots,* 14 FOR. SCI. INT'L 1 (1979).

[142] *See generally* Lee, Ludwig & Baden, *Matrix Proteins of Human Hair as a Tool for Identification of Individuals,* 11 FOR. SCI. 115 (1978).

[143] *See* text accompanying notes 235-39 *infra.*

protein groups occur.[144] We know, for instance, what percentage of the population falls into the type A blood grouping.[145] In other words, the application of serological techniques to hair analysis will enable analysts to define the probative value of their findings quantitatively.

L. *Determining Which Person Was the Human Hair Source*

The finding of most acute interest to the criminal justice system is, of course, the identification of the specific person who was the source of the human hair. The current state of the art does not allow the hair analyst to make a conclusive identification,[146] but there are several techniques that the analyst can utilize to narrow the class of possible sources. Two of the techniques, the conventional microscope and NAA, have already gained judicial acceptance, but there are several other promissing techniques vying for acceptance in the court room.

One new technique, ion microprobe, failed its first judicial test in *United States v. Brown*.[147] This technique depends upon the measurement of the number and mass of ions that the sample releases when the sample is struck by an ion beam.[148] The instrumentation consists of two mass spectrometers. One spectrometer generates a magnetic field. The field is aimed as a beam at the sample. When the beam strikes the sample, the sample casts off ions of varying mass and numbers. These ions are collected and analyzed by the second mass spectrometer. The analysis yields the concentration of trace elements in the sample.

In *Brown*, the prosecution witnesses relied on ion microprobic analysis as the basis for their conclusion that the hair samples had a common origin.[149] The trial judge admitted the evidence, but the Sixth Circuit reversed.[150] The court cited *Frye v. United States*[151] as authority for its decision.[152] *Frye* is the leading case announcing that a novel scientific technique must have gained general acceptance within the relevant scientific circle in order to be admissible.[153] In *Brown*, the record indicated that there were no prior cases admitting ion microprobic hair

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[144] Wraxall, *Forensic Serology*, in Imwinkelried, *supra* note 28, at 940-41.

[145] MOENSSENS & INBAU, *supra* note 40, at 298.

[146] State v. Hunt, 53 Wis. 2d 734, 750-51, 193 N.W.2d 858, 867-68 (1972); MOENSSENS & INBAU, *supra* note 40, at 406; 27 AM. JUR. PROOF OF FACTS *Identification of Hit-and-Run Vehicle and Driver* 287, 307 (1971).

[147] 557 F.2d 541 (6th Cir. 1977).

[148] *Id.* at 555.

[149] *Id.*

[150] *Id.*

[151] 293 F. 1013 (D.C. Cir. 1923).

[152] 557 F.2d at 557.

[153] 293 F. at 1014; *see* Giannelli, *The Admissibility of Novel Scientific Evidence:* Frye v. United States, *A Half Century Later*, 80 COLUM. L. REV. 1197, 1205 (1980) [hereinafter cited as Giannelli]; text accompanying notes 206-25 *infra*.

analysis and, worse still, there were no technical journal articles discussing the application of ion microprobe to hair examination.[154] Given *Frye*, the record condemned the ion microprobe evidence to inadmissibility.

Three other novel hair examination techniques have yet to surface in the courtroom. One is pyrolysis gas chromatography (PGC).[155] Chromatography techniques are designed to separate the constituent chemicals in compounds. In PGC, a pyrolyser breaks the sample down into fragments. The fragments (the pyrolysate) are then swept into the PGC column. Each chemical element requires a unique period of time to migrate through the column—its retention time.[156] As each element exits the column, the instrumentation marks a peak on a chart or chromatogram. The chart depicts the spectra of the compound; a peak appears on the chart as each element leaves the column.[157]

Researchers believe that PGC has tremendous potential as a method of individualizing human hair.[158] However, at present, PGC is far from realizing that potential. Even neighboring hairs from the same human head produce different spectra on gas chromatograms.[159] In addition, researchers have accumulated only a limited number of reference PGC spectra for comparison purposes.[160] Finally, many agents such as sprays, shampoos, rinses, dyes, and bleaches are applied to human hair, and little is known about the effect of these agents on gas chromatograms.[161]

Like PGC, pyrolysis mass spectrometry (Py-MS) may ultimately prove to be of great value in individualizing human hair.[162] As in PGC, the process begins with the breakdown of the sample into a pyrolysate of fragments.[163] The difference is that in Py-MS, the pyrolysate next enters a mass spectrometer. The fragments are ionized and analyzed. The end product is a mass pyrogram, indicating the elements present in the sample.[164]

The proponents of Py-MS argue that it has several advantages over PGC. They claim that Py-MS is a faster technique and that Py-MS instrumentation is more standardized, permitting one analyst to easily

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[154] 557 F.2d at 557.

[155] *See* 22 AM. JUR. PROOF OF FACTS *Identification of Substances by Instrumental Analysis* 86-87 (Supp. 1981) [hereinafter cited as *Identification by Instrumental Analysis*].

[156] *See* Rudzitis, *New Techniques for Pyrolysis Gas Chromatrography and Possible Other Forensic Applications*, 62 J. CRIM. L.C. & P.S. 298, 299 (1971) [hereinafter cited as Rudzitis].

[157] *Id.*

[158] *See Identification by Instrumental Analysis*, *supra* note 155, at 88.

[159] *Id.* at 87.

[160] Rudzitis, *supra* note 156, at 298.

[161] *Identification by Instrumental Analysis*, *supra* note 155, at 88.

[162] *See* Hughes, Wheals & Whitehouse, *Pyrolysis Mass Spectrometry, A Technique of Forensic Potential?*, 10 FOR. SCI. 217, 218 (1977).

[163] *Id.* at 217.

[164] *Id.*

duplicate and doublecheck the analysis performed by another analyst.[165] However, there has been little research on Py-MS. For that reason, it is often difficult to properly interpret the pyrogram to deduce the identity of the pyrolysate.[166] Like PGC, Py-MS has not yet advanced to the point that the analyst can confidently individualize hair samples on the basis of Py-MS alone.

The third technique to make its advent recently is SEM.[167] SEM represents a quantum leap in microscopy. Even with the best conventional optical microscopes, the greatest possible magnification is a power of 2,000.[168] SEM is a fundamentally different methodology and can attain much greater magnification. In SEM, the sample is scanned with a beam of electrons.[169] The scan causes the sample to emit secondary electrons. SEM collects and analyzes these electrons. The analysis converts the electrons into a point-by-point image of the sample.[170] This electrical image magnifies the sample by a power of 100,000.[171] Thus, the analyst can now observe objects and characteristics that were previously invisible to both the naked eye and the very best optical microscope.

SEM specialists have begun to apply SEM to hair examination.[172] The application of SEM to hair examination creates the possibility of detecting minute hair characteristics peculiar to the individual human source. SEM researchers, though, have not as yet claimed that capability. However, as previously noted, they have asserted that SEM enabled the analyst to observe detailed anatomical features in the medulla that will conclusively differentiate human from animal hairs.[173] In the long run, SEM may hold the greatest promise for modernizing the science of hair analysis.[174]

Although hair analysis by ion microprobe, PGC, Py-MS, and SEM have not yet won judicial sanction, there are two techniques that are well accepted: conventional microscopy and NAA. Researchers are attempting to perfect both techniques by developing data bases to quantify the individuation of the hair samples.

Conventional microscopists concede now, as they did when *Knoll* was decided, that their technique cannot positively, conclusively identify

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[165] *Id.* at 218.

[166] *Id.*

[167] *See* Verhoeven, *The Advantages of the Scanning Electron Microscope in the Investigative Studies of Hair,* 63 J. CRIM. L.C. & P.S. 125, 125 (1972) [hereinafter cited as Verhoeven].

[168] People v. Palmer, 80 Ca. App. 3d 239, 251 n.2, 145 Cal. Rptr. 466, 471 n.2 (1978).

[169] Judd, *Scanning Electron Microscopy as Applied to Forensic Evidence Analysis,* in Imwinkelried, *supra* note 28, at 873.

[170] *Id.*

[171] *Id.* at 879-80.

[172] Clement, *supra* note 72, at 447; Verhoeven, *supra* note 167, at 125.

[173] *See* text accompanying note 72 *supra.*

[174] *See* Clement, *supra* note 72, at 457.

the human hair source.[175] But it would be a mistake to conclude that the state of their art has not progressed in the past century. Hair analysts are now conducting several research projects to develop better systems for evaluating the significance of the data yielded by conventional microscopy.[176]

One research project involves scale counts. Two researchers have claimed that: (1) the scale count of even a single hair strand is nearly always representative of all scalp hairs;[177] and (2) while the average or mean scale count is constant for the individual, the count differs significantly from person to person.[178] One commentator has expressed skepticism about the utility of scale counts to individualize human hair sources.[179] To begin with, this critic points out that the research project had a very limited data base—initially only thirty nine hair samples.[180] The critic conducted his own independent tests to doublecheck the findings of the proponents of the scale count technique, and his test results seemingly contradict the proponents' findings.[181] He concluded that "the value of the scale count in eliminating or 'individualizing' an evidence hair with one from the suspect is to be seriously questioned."[182]

A second research project is under way in Canada. Canadian researchers have catalogued twenty three different characteristics such as color, pigment distribution, maximum diameter, shaft length, and scale count that microscopists have relied on in the past to differentiate hair sources.[183] For each characteristic, the researchers developed subcategories.[184] For instance, characteristic *O*, length, is subdivided into five groups, depending on the strand's length in inches.[185] The researchers found that if two samples matched in all respects, the odds were only one in 4,500 that the samples originated from different human hair sources.[186] At this juncture, neither the technique nor the statistical estimates based on the technique may be ripe for courtroom use. As in

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[175] *See* text accompanying note 235 *infra*.

[176] *See* text accompanying notes 177-91 *infra*. *See also* Saferstein, *Criminalistics—A Look Back at the 1970s, a Look Ahead to the 1980s*, 24 J. FOR. SCI. 925, 925-30 (1979).

[177] Gamble & Kirk, *Human Hair Studies. II. Scale Counts*, 31 J. AM. INST. CRIM. L. & CRIM. 627, 629 (1941) [hereinafter cited as Gamble & Kirk].

[178] *Id.* at 631. *See also* Kirk & Gamble, *Further Investigation of the Scale Count of Human Hair*, 33 J. CRIM. L. & CRIM. 276, 280 (1942).

[179] Beeman, *The Scale Count of Human Hair*, 32 J. CRIM. L. & CRIM. 572, 574 (1942) [hereinafter cited as Beeman].

[180] *Id.* at 572; *see* Gamble & Kirk, *supra* note 177, at 631.

[181] Beeman, *supra* note 179, at 572.

[182] *Id.* at 574. *See also* Beeman, *Further Evaluation of the Scale Count of Human Hair*, 33 J. CRIM. L. & CRIM. 422, 424 (1943).

[183] Gaudette & Keeping, *An Attempt at Determining Probabilities in Human Scalp Hair Comparison*, 19 J. FOR. SCI. 599, 601-02 (1974).

[184] *Id.*

[185] *Id.* at 602.

[186] *Id.* at 604-05.

the case of the scale count project, this project involved a small data base: only 100 persons.[187] Even within that small sample, the researchers found several indistinguishable hair samples from different persons.[188] Additionally, the researchers acknowledge that some of the categorization is subjective; for example, the analyst must exercise subjective judgment in categorizing hair samples under factor *A*, color, and factor *E*, texture.[189] One court liberally permitted an analyst to testify to the one in 4,500 estimate,[190] but two courts have held that there has been insufficient experimental verification of that estimate.[191]

In short, the attempts to quantify the data generated by conventional microscopy have met with only limited success. Much more progress has been made toward quantifying the data generated by the last individualization technique, NAA.[192] In NAA, the sample is placed in a research type reactor and bombarded with neutrons. The bombardment makes the sample artifically radioactive. In that condition, the sample emits gamma rays. The instrument collects and measures the gamma rays. The gamma ray energy levels are peculiar to the chemical elements present in the sample. By analyzing the gamma rays, NAA yields both qualitative and quantitative data; NAA enables the analyst to both identify and measure the trace elements present.[193] NAA instruments can measure a quantity as small as one ten millionth of a microgram.[194]

There has been substantial NAA research to determine the occurrence of trace elements in human hair.[195] The research has given many observers hope that NAA will allow much more reliable individualization than in the past. The problem that has arisen is that even among the

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[187] *See id.* at 599.

[188] *Id.* at 603.

[189] *Id.* at 605.

[190] People v. DiGiacomo, 71 Ill. App. 3d 56, 58, 388 N.E.2d 1281, 1282-83 (1979).

[191] United States v. Massey, 594 F.2d 676, 680 (8th Cir. 1979); State v. Carlson, ___ Minn. ___, ___, 267 N.W.2d 170, 176 (1978).

[192] *See* 15 AM. JUR. PROOF OF FACTS *Identification of Substances by Neutron Activation Analysis* 115-23 (1964) [hereinafter cited as *Identification by NAA*]; *see* Krishnan, *Neutron Activation Analysis and Atomic Absorption Spectrometry*, in Imwinkelried, *supra* note 28, at 279.

[193] United States v. Stifel, 433 F.2d 431, 436 (6th Cir. 1970), *cert. denied*, 401 U.S. 994 (1971).

[194] *Identification by NAA*, *supra* note 192, at 124.

[195] *Id.* at 131. *See, e.g.*, Cornelis, *Is It Possible to Identify Individuals by Neutron Activation Analysis of Hair?*, 12 MED., SCI. & L. 188 (1972); Perkons, *Individualization of Human Head Hair*, in PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON FORENSIC ACTIVATION ANALYSIS 221 (V. Guinn ed. 1967); Perkons & Jervis, *Hair Individualization Studies*, in PROCEEDINGS OF THE 1965 INTERNATIONAL CONFERENCE ON MODERN TRENDS IN ACTIVATION ANALYSIS 295 (1965); Lima, Shibata & Atalla, *Activation Analysis Applied to Forensic Investigation: Some Observations on the Problem of Human Hair Individualization*, in I RADIOCHEMICAL METHODS OF ANALYSIS 119 (International Atomic Energy Agency 1965).

hairs of a single person, there are hair-to-hair variations in trace element concentrations.[196] Research efforts recently have focused on the attempt to determine mean values and standard deviations in hair trace element concentrations that will permit conclusive individualization.[197]

II. The Underemployment of Hair Analysis Evidence

It should be evident by now that the science of hair analysis has made major strides in the century since *Knoll*. The scientific journals document that the modern hair analyst has tools far more powerful than the microscope used in *Knoll* and that the analyst can make many findings more specific than the general conclusion that two hair samples appear similar. Yet even the most recent reported cases hardly suggest the scientific progress that has been made. It is almost as if the criminal justice system has been blind to the progress the laboratories have made since 1882.

For their part, prosecutors have not employed hair analysis evidence to its full potential. In a few cases, prosecutors have resorted to the more sophisticated techniques such as NAA[198] and gas chromatography.[199] However, in the overwhelming majority of cases, prosecutors have been content to reprise *Knoll* and offer hair testimony based on microscopy.[200] Even when using the more sophisticated methods, prosecutors often elicit only the bland testimony that the hair samples are "alike."[201] Some of the trial techniques manuals for prosecutors encourage them to offer hair evidence, but by and large the sample lines of questioning in these manuals outline the presentation of conclusory opinions based on microscopy.[202]

Defense counsel are as guilty as prosecutors of underemploying hair evidence. It is true that defense counsel have occasionally rebutted prosecution hair evidence with contrary expert testimony.[203] However, those cases are in the distinct minority. In most cases, there is no indication that there was defense hair evidence.[204] Worse still, in most cases involving prosecution hair testimony based on conventional microscopy,

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[196] *See Evidentiary Uses of NAA*, *supra* note 93, at 1039.

[197] *See id.* at 1039-42.

[198] *See, e.g.*, State v. Breest, 116 N.H. 734, 740, 367 A.2d 1320, 1332 (1976); People v. Collins, 43 Mich. App. 259, 264, 204 N.W.2d 290, 293 (1972), *cert. denied*, 419 U.S. 866 (1974); State v. Holt, 17 Ohio St. 2d 81, 84, 246 N.E.2d 365, 367 (1969).

[199] *See, e.g.*, State v. Perryman, 520 S.W.2d 126, 129 (Mo. App. 1975).

[200] *See* notes 234-39 *infra*.

[201] *See, e.g.*, State v. Breest, 116 N.H. 734, 740, 367 A.2d 1320, 1332 (1976).

[202] *See, e.g.*, E. SALCINES, TRIAL MANUAL ON PREDICATE QUESTIONS 23 (1977). This sample line of questioning refers vaguely to "examinations or tests." *Id. See also Hair*, *supra* note 40, at 578-87 (more detailed sample line of questioning).

[203] *See, e.g.*, Benton v. State, 86 Okla. Crim. 137, 145-46, 190 P.2d 168, 172 (1948).

[204] *See, e.g.*, State v. Morris, 26 Ariz. App. 342, 343-44, 548 P.2d 435, 436-37 (1976); Commonwealth v. Tarver, 369 Mass. 302, 310-11, 345 N.E.2d 671, 677 (1975).

there is no suggestion that the defense even pointed out to the jury that there are more reliable scientific techniques that the prosecution neglected to use.[205]

The underemployment of hair evidence in criminal cases would be more understandable if the courts had erected strict evidentiary barriers against the admission of hair analysis testimony. But the courts have not done so. Neither the general evidence law governing scientific proof nor the case law specifically addressing hair analysis creates a formidable barrier.

As previously stated, *Frye v. United States* is the controlling precedent in most American jurisdictions, laying down the general test for the admissibility of scientific evidence.[206] That case teaches that it is not enough that the expert vouches that in his or her personal opinion, the scientific technique is valid; the expert must add that as a matter of historical fact, the technique has gained general acceptance within the pertinent scientific circle.[207] Notwithstanding *Frye*, hair evidence can be liberally admitted in most American jurisdictions.

Some jurisdictions have abandoned *Frye* and liberalized their general test for admitting scientific evidence.[208] In Florida,[209] Iowa,[210] New York,[211] and Utah,[212] courts have overturned *Frye* by decisional law; these jurisdictions require only that the expert personally vouch for the theory and technique. In Ohio,[213] New Mexico,[214] and at least one federal jurisdiction,[215] courts have held that the defendant has a constitutional right to present critical scientific evidence even when the evidence would not pass muster under *Frye*. Perhaps most significantly, the Second Circuit[216] and the Maine Supreme Judicial Court[217] have construed the new Federal Evidence Rules as impliedly overruling *Frye*. The Rules are now in effect in over twenty American jurisdictions.[218] If most of

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[205] *See* note 235 *infra*.

[206] Giannelli, *supra* note 153, at 1205; *see* text accompanying note 153 *supra*.

[207] 293 F. at 1014.

[208] *See* Giannelli, *supra* note 153, at 1233-35.

[209] *See* Coppolino v. State, 223 So. 2d 68, 70 (Fla. Dist. Ct. App. 1968), *app. dismissed*, 234 So. 2d 120 (Fla. 1969), *cert. denied*, 399 U.S. 927 (1970).

[210] *See* State v. Hall, 297 N.W.2d 80, 85 (Iowa 1980) (blood splatter evidence).

[211] *See* People v. Daniels, 102 Misc. 2d. 540, 545-46, 422 N.Y.S.2d 832, 837 (1979) (polygraph).

[212] *See* Phillips v. Jackson, 615 P.2d 1228, 1234-35 (Utah 1980) (human leucocyte antigen test result evidence).

[213] *See* State v. Sims, 52 Ohio Misc. 31, 70-71, 369 N.E.2d 24, 46 (1977) (polygraph).

[214] *See* State v. Dorsey, 87 N.M. 323, 325, 532 P.2d 912, 914 (Ct. App.), *aff'd*, 88 N.M. 184, 539 P.2d 204 (1975) (polygraph).

[215] Jackson v. Garrison, 495 F. Supp. 9, 11 (W.D.N.C. 1979) (polygraph).

[216] United States v. Williams, 583 F.2d 1194, 1198, 1200 (2d Cir. 1978), *cert. denied*, 439 U.S. 1117 (1979) (sound spectrography).

[217] State v. Williams, 388 A.2d 500, 503-04 (Me. 1978) (sound spectrography).

[218] Giannelli, *supra* note 153, at 1228 n.241.

those jurisdictions adopt the position of Maine and the Second Circuit, *Frye* may soon become a minority view.

Even in jurisdictions adhering to *Frye*, the test should not materially limit the ability of prosecutors and defense counsel to introduce hair analysis evidence. *Frye* mandates that the proponent of scientific proof establish that the technique has gained general acceptance within "the relevant scientific circle."[219] Like most contemporary intellectual disciplines, science is highly compartmentalized and specialized.[220] For that reason, courts tend to define the relevant scientific field rather narrowly.[221] Ordinarily, the proponent need demonstrate acceptance only within the restricted circle of specialists "who would be expected to be familiar" with the technique.[222] In addition, although the proponent must prove acceptance within the pertinent scientific community to satisfy *Frye*, there is no need to establish prior acceptance by the courts.[223] If the proponent can demonstrate that the scientific specialists acknowledge the technique, it is no bar to admissibility that the technique has never before been introduced in court.[224] Given the large number of scientific journals and the other rapid communications facilities within the scientific community, a new scientific technique can gain acceptance rapidly and thus quickly comply with *Frye*. The swift judicial acceptance of SEM is a case in point.[225] Hence, *Frye* does not pose an insuperable barrier to the admission of hair evidence; and it therefore cannot account for the underemployment of hair analysis.

In addition, the case law specifically analyzing the admissibility of hair testimony does not account for the underemployment of hair analysis. The cases in which courts have excluded hair evidence are so rare that they literally amount to only a handful of precedents. In *Brown*, ion microprobic hair analysis was excluded becauses there was absolutely no evidence of compliance with *Frye*.[226] In another case, the court found the analyst's testimony too vague and speculative to be helpful to the jury.[227] In two remaining cases, in which the prosecution offered statistical evidence to quantify the individualization of the hair samples, the courts concluded that the prosecution's foundation was inadequate.[228]

In contrast to these few cases excluding hair evidence, a large body

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[219] *See* 293 F. at 1014; Giannelli, *supra* note 153, at 1210.

[220] People v. Williams, 164 Cal. App. 2d Supp. 858, 862, 331 P.2d 251, 253-54 (1958).

[221] *See id.*; Huntingdon v. Crowley, 64 Cal. 2d 647, 656, 414 P.2d 382, 390, 51 Cal. Rptr. 254, 262 (1966).

[222] *See* note 221 *supra*.

[223] *See* People v. Palmer, 80 Cal. App. 3d 239, 252, 145 Cal. Rptr. 466, 472 (1978).

[224] *See id.*

[225] *Id.*

[226] *See* text accompanying notes 147-54 *supra*.

[227] People v. Roff, 67 A.D.2d 805, 805-06, 413 N.Y.S.2d 43, 44-45 (1979).

[228] United States v. Massey, 594 F.2d 676, 681 (8th Cir. 1979); State v. Carlson, ____ Minn. ____, ____, 267 N.W.2d 170, 176 (1978).

of case law reflects the courts' receptivity to hair analysis. Courts unhesitatingly permit analysts to opine on the threshold question whether the material is hair.[229] Courts also allow analysts to testify on more particular issues such as whether the hair is of human origin,[230] the age of the human hair source,[231] the source's race,[232] and the region of the body in which the hair strand originated.[233]

Courts have been equally liberal in admitting evidence offered to individualize the human hair source. Repeatedly, 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.[234] Courts consistently allow the analyst's testimony even when the analyst admits the inconclusive nature of a microscopic identification.[235] The analyst is permitted to

[229] Murray v. State, 202 Miss. 849, 852-53, 32 So. 2d 789, 790 (1948); State v. Harris, 241 Or. 224, 243, 405 P.2d 492, 500-01 (1965).

[230] Harnage v. State, 49 Ala. App. 563, 577-80, 274 So. 2d 333, 348-50, *rev'd on other grounds*, 49 Ala. 674, 274 So. 2d 352 (1972); Ward v. Music, 257 S.W.2d 516, 520 (Ky. 1953); Acrey v. Commonwealth, 312 Ky. 732, 735, 229 S.W.2d 748, 751 (1950); Wright v. State, 422 S.W.2d 184, 188 (Tex. Crim. App. 1967), *modified*, 408 U.S. 934 (1972).

[231] Commonwealth v. McGarty, 323 Mass. 435, 439, 82 N.E.2d 603, 606 (1948).

[232] Harnage v. State, 49 Ala. App. 563, 577-80, 274 So. 2d 333, 348-49, *rev'd on other grounds*, 49 Ala. 674, 274 So. 2d 352 (1972); Thomas v. State, 374 So. 2d 508, 514 (Fla. 1979), *cert. denied*, 445 U.S. 972 (1980); People v. Kirkwood, 17 Ill. 2d 23, 32, 160 N.E.2d 766, 772 (1959), *cert. denied*, 363 U.S. 847 (1960); State v. Wilson, 217 La. 470, 478, 46 So. 2d 738, 741 (1950), *aff'd*, 341 U.S. 901 (1951); State v. Ray, 274 N.C. 556, 574, 164 S.E.2d 457, 468 (1968); Benton v. State, 86 Okla. Crim. 137, 145-46, 190 P.2d 168, 172 (1948).

[233] Harnage v. State, 49 Ala. App. 563, 577-80, 274 So. 2d 333, 348-49, *rev'd on other grounds*, 49 Ala. 674, 274 So. 2d 352 (1972); Commonwealth v. McGarty, 323 Mass. 435, 439, 82 N.E.2d 603, 606 (1948); State v. Golladay, 78 Wash. 2d 121, 144, 470 P.2d 191, 205 (1970).

[234] United States v. Brady, 595 F.2d 359, 362-63 (6th Cir.), *cert. denied*, 444 U.S. 862 (1979); United States v. Cyphers, 553 F.2d 1064, 1072-73 (7th Cir.), *cert. denied*, 434 U.S. 843 (1977); State v. Blazak, 114 Ariz. 199, 203, 560 P.2d 54, 58 (1977); People v. Carter, 48 Cal. 2d 737, 743, 312 P.2d 665, 668 (1957); Ward v. Music, 257 S.W.2d 516, 520 (Ky. 1953); State v. Wilson, 217 La. 470, 478, 46 So. 2d 738, 741 (1950), *aff'd*, 341 U.S. 901 (1951); Commonwealth v. Tarver, 369 Mass. 302, 310-11, 345 N.E.2d 671, 677 (1975); People v. Watkins, 78 Mich. App. 89, 95-96, 259 N.W.2d 381, 384-85 (1977); State v. Carlson, ___ Minn. ___, ___, 267 N.W.2d 170, 175 (1978); People v. Allweiss, 48 N.Y.2d 40, 49-50, 396 N.E.2d 735, 740 (1979); State v. Earley, 118 R.I. 205, 209, 373 A.2d 162, 165 (1977); State v. Andrews, 86 R.I. 341, 345, 134 A.2d 425, 430-31, *cert. denied*, 355 U.S. 898 (1957); Skinner v. Commonwealth, 212 Va. 260, 262, 183 S.E.2d 725, 727 (1971); State v. Golladay, 78 Wash. 2d 121, 144, 470 P.2d 191, 205 (1970).

[235] United States v. Brady, 595 F.2d 359, 362-63 (6th Cir.), *cert. denied*, 444 U.S. 862 (1979); Harnage v. State, 49 Ala. App. 563, 577-80, 274 So. 2d 333, 348-49, *rev'd on other grounds*, 49 Ala. 674, 274 So. 2d 352 (1972); People v. Allen, 41 Cal. App. 3d 196, 201, 115 Cal. Rptr. 839, 842 (1974); Fultz v. State, 265 Ind. 626, 634-35, 358 N.E.2d 123, 128 (1976); State v. Huckaby, ___ La. ___, ___, 368 So. 2d 1059, 1063-64 (1979); State v. Wilson, 217 La. 470, 478, 46 So. 2d 738, 741 (1950), *aff'd*, 341 U.S. 901 (1951); People v. Allweiss, 48 N.Y.2d 40, 49-50, 396 N.E.2d 735, 740 (1979); Benton v. State, 86 Okla. Crim. 137, 145-46, 190 P.2d 168, 172 (1948); State v. Harris, 241 Or. 224, 243, 405 P.2d 492, 500-01 (1965); State v. Vargus, 118 R.I. 113, 126-27, 373 A.2d 150, 156-57 (1977); State v. Batten, 17 Wash. App. 428, 437-38, 563 P.2d 1287, 1292-93 (1977); State v. Bauman, 77 Wash. 2d 938, 940-41, 468 P.2d 684, 686 (1970).

give such vague testimony as the opinions that the hair samples are "similar,"[236] "of the same general character,"[237] "consistent" with the assumption of a common source,[238] or "could" have come from the same origin.[239] The massive body of case law,[240] liberally admitting even hair evidence of low probative value, dwarfs the handful of cases excluding hair evidence.

III. The Case for the Greater Use of Hair Analysis Evidence

The previous section demonstrates that evidence law is not the cause of the underemployment of hair analysis. Quite to the contrary, most jurisdictions are receptive to hair analysis testimony; and the evidence law in those jurisdictions seemingly would not preclude the more extensive use of hair testimony. If evidence law is not a bar, the only remaining issue is the policy question: Would it be wise to move in that direction?

We noted at the outset of this article that there is a plausible argument that we should not rely more extensively on hair analysis. It is argued that the standards for analyzing hair are so soft that the jury cannot properly evaluate the weight of the testimony.[241] Hair analysts themselves have characterized their interpretive standards as "subjective."[242] Further, the Laboratory Proficiency Testing Program disclosed a frighteningly high percentage of error in hair analysis.[243] If these arguments have merit, the conclusion seems unavoidable that we should decrease our reliance on hair evidence rather than move in the other direction. However, the position of this article is that such a conclusion is wrong. Greater use of hair evidence—especially the more sophisticated

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[236] United States v. Brady, 595 F.2d 359, 362-63 (6th Cir.), *cert. denied*, 444 U.S. 862 (1979); Harnage v. State, 49 Ala. App. 563, 577-80, 274 So. 2d 333, 348-50, *rev'd on other grounds*, 49 Ala. 674, 274 So. 2d 352 (1972); State v. Blazak, 114 Ariz. 199, 203, 560 P.2d 54, 58 (1977); People v. Abbott, 47 Cal. 2d 362, 368, 303 P.2d 730, 734 (1956); People v. Kirkwood, 17 Ill. 2d 23, 32, 160 N.E.2d 766, 772 (1959), *cert. denied*, 363 U.S. 847 (1960); Acrey v. Commonwealth, 312 Ky. 732, 735, 229 S.W.2d 748, 751 (1950); State v. Huckaby, ___ La. ___, ___, 368 So. 2d 1059, 1063-64 (1979); State v. Wilson, 217 La. 470, 478, 46 So. 2d 738, 741 (1950), *aff'd*, 341 U.S. 901 (1951); State v. Carlson, ___ Minn. ___, ___, 267 N.W.2d 170, 175 (1978); State v. Perryman, 520 S.W.2d 126, 130 (Mo. App. 1975); Benton v. State, 86 Okla. Crim. 137, 145-46, 190 P.2d 168, 172 (1948); Wright v. State, 422 S.W.2d 184, 188 (Tex. Crim. App. 1967), *modified*, 408 U.S. 934 (1972); Skinner v. Commonwealth, 212 Va. 260, 262, 183 S.E.2d 725, 727 (1971).

[237] State v. Baldwin, 47 N.J. 379, 392, 221 A.2d 199, 206, *cert. denied*, 385 U.S. 980 (1966).

[238] People v. Allen, 41 Cal. App. 3d 196, 201, 115 Cal. Rptr. 839, 842 (1974).

[239] United States v. Cyphers, 553 F.2d 1064, 1072 (7th Cir.), *cert. denied*, 434 U.S. 843 (1977); State v. Batten, 17 Wash. App. 428, 437-38, 563 P.2d 1287, 1292-93 (1977).

[240] Notes 229-39 *supra*, collect cases from 22 jurisdictions.

[241] Coleman & Walls, *supra* note 29, at 280; *see* text accompanying notes 29-31 *supra*.

[242] *See* United States v. Brown, 557 F.2d 541, 555 (6th Cir. 1977) (noting admission of Kenneth Snow of Bureau of Alcohol, Tobacco and Firearms that "visual comparison of hair is a subjective test").

[243] *See* text accompanying notes 33-38 *supra*.

tests for sex and blood grouping—will result in better trial advocacy and more trustworthy fact-finding.

A. *More Persuasive Trial Advocacy*

Prosecutors can improve the quality of their trial advocacy by presenting detailed and specific hair evidence. In the past, many prosecutors offering hair evidence have been content to elicit vague "similarity" testimony based on conventional microscopy.[244] The modern state of the art of hair analysis permits prosecutors to present much more detailed and specific testimony. In other areas of trial work, especially insanity cases, experienced prosecutors have found that more specific, concrete testimony is preferable.[245] The optimal prosecution strategy in insanity cases is to rivet the jury's attention on the concrete testimony about the defendant's apparently rational, calculated conduct before, during, and after the offense[246] while simultaneously belittling the subjectivity of abstract, defense psychiatric testimony.[247]

Modern linguistics research confirms this conclusion that experienced prosecutors have reached intuitively. The Duke Law and Language Project has studied the effects of using concrete and abstract diction on jury decision-making.[248] The Project found that concrete testimony favors the prosecution and that abstract testimony helps the defense.[249] Specific testimony is more likely to produce the certainty requisite for a guilty finding, and vague testimony tends to generate the doubt that prompts acquittals.[250] The lesson for the prosecutor is evident: Whenever possible, the goverment should present specific, concrete testimony. The application of that lesson to hair analysis leads to the conclusion that prosecutors no longer should be content with eliciting indefinite opinions that hair samples are merely "similar" or "consistent" with the assumption that the samples originate from a common source. It makes much more sense for prosecutors to attempt to introduce specific Y-chromosome test evidence to determine the sex of the human hair source or blood grouping evidence to quantify the individualization of the hair source.

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[244] *See* note 236 *supra*.

[245] Rook, *Take the High Ground: A Practical Approach to Meeting the Insanity Defense*, in THE PROSECUTOR'S DESKBOOK 598, 598-99 (P. Healy & J. Manak eds. 1971) [hereinafter cited as PROSECUTOR'S DESKBOOK].

[246] Alexander, *Meeting the Insanity Defense*, in PROSECUTOR'S DESKBOOK, *supra* note 245, at 592, 593; Zagel, *Psychiatric Issues and Criminal Law: The Prosecution Viewpoint*, in PROSECUTOR'S DESKBOOK, *supra* note 245, at 575, 576.

[247] Rook, *Take the High Ground: A Practical Approach to Meeting the Insanity Defense*, in PROSECUTOR'S DESKBOOK, *supra* note 245, at 600; Younger, *Diminished Capacity: A Principle in Search of Refinement*, in PROSECUTOR'S DESKBOOK, *supra* note 245, at 584, 588.

[248] Parkinson & Parkinson, *Speech Tactics for Successful Trials*, TRIAL, Sept. 1979, at 36.

[249] *Id.*

[250] *Id.*

For a different reason, defense counsel should use hair analysis more extensively. In a few reported cases, the court's opinion indicates that the defense called the jury's attention to the fact that the prosecution neglected to use more reliable and sophisticated techniques.[251] When the prosecution resorts to scientific evidence such as hair analysis, stressing "the path not taken" is often the most effective defense strategy.[252] Professor Lewis has remarked that the analyst's choice of an inferior scientific technique can be the source of the reasonable doubt that the defense needs to obtain an acquittal:

> Whenever a scientist undertakes to solve any problem, several alternative procedures are available. Each has its own built-in potential for uncertainty or error. Resort to any scientific procedures implies a willingness on the part of the experimenter to accept error of the type and magnitude inherent in the chosen method.[253]

Professor Lewis uses hair examination as a premier example of this strategy.[254] Lewis stresses the limited probative value of microscopic hair examination.[255] He notes that a conventional microscope can easily miss "inclusionary and exclusionary indicia that might appear clearly under SEM examination."[256] Conventional microscopy is "less exact"[257] than SEM. By familiarizing the jury with the more precise techniques the prosecution overlooked, the defense may win an acquittal.[258] When the prosecution employs only conventional microscopy, the prosecution simply has not done everything within its power to remove the doubt about the defendant's guilt. More sophisticated hair analysis techniques might have revealed differences between the hair samples that would have exculpated the defendant, and the jury may find this room for doubt decisive.[259]

B. *More Reliable Fact-Finding*

The fact that greater use of hair evidence would improve criminal trial advocacy cuts in favor of ending the underemployment of hair analysis. However, that advantage is not responsive to the critics' argument that hair analysis is intolerably subjective and error prone. If hair analysis is so inaccurate, substance should prevail over form: It is

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[251] Lewis, *The Element of Subjectivity in Interpreting Instrumental Test Results*, in Imwinkelried, *supra* note 28, at 409.

[252] *Id.*

[253] *Id.* at 414-15.

[254] *Id.* at 415-16.

[255] *Id.* at 415.

[256] *Id.* at 415-16.

[257] *Id.* at 416.

[258] *Id.* at 414-16.

[259] *Id.* at 415-16.

argued that even if the presentation of additional hair evidence would superficially appeal to jurors, the evidence should be excluded to protect the integrity of fact-finding.

This argument is specious. Minimizing reliance on hair evidence would increase the reliability of fact-finding only if the net result were increasing reliance on more trustworthy evidence. That would not be the case. Less reliance on scientific evidence such as hair analysis would increase our dependence on lay eyewitness testimony. Witness psychology has indicted lay eyewitness testimony even more damningly than the Laboratory Proficiency Testing Program has done to hair evidence.[260] The 1979 case of *State v. Pagano*[261] dramatized the unreliability of eyewitness testimony. In that case, the eyewitnesses to a series of robberies uniformly identified Father Bernard Pagano as the "Gentleman Bandit" who committed the robberies.[262] Later another man, Ronald Clouser, came forward and confessed to the robberies.[263] *Pagano* is not an isolated case; it is merely one of the numerous examples of the untrustworthiness of observations by untrained laypersons in stressful situations.[264] In their classic article, Levine and Tapp summarize the large number of witness psychology experiments exposing weaknesses in such observations.[265] In one experiment by Doctor Buckout, only 14.7 percent of the eyewitnesses to a simulated crime correctly identified the perpetrator.[266] The critics of hair evidence may be able to point to the Laboratory Proficiency Testing Program as support for their position, but the experiments and studies impeaching lay testimony are far more numerous. Hair analysis may be subject to error, but it would be foolish to place even greater reliance on lay eyewitness testimony. There is now experimental data indicating that lay jurors are more willing to convict on the basis of fallible eyewitness testimony than on the basis of the highest caliber scientific evidence such as fingerprint analysis.[267]

Moreover, if the attacks on the subjectivity and inaccuracy of hair analysis are properly understood, both attacks are in reality arguments

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[260] Buckout & Greenwald, *Witness Psychology*, in Imwinkelried, *supra* note 28, at 1291.

[261] *Id.* at 1321-26.

[262] *Id.*

[263] *Id.*

[264] *Id.* at 1325.

[265] Levine & Tapp, *The Psychology of Criminal Identification: The Gap from* Wade *to* Kirby, 121 U. PA. L. REV. 1079 (1973).

[266] *Id.* at 1298.

[267] The N.Y. Times, March 17, 1981, at Y-16, described a recent experiment by Dr. Elizabeth Loftus, noted witness psychologist:

> In research in which Dr. Loftus asked participants to convict a defendant accused of passing a bad check, almost 80 percent of those presented with eyewitness testimony to the crime were willing to convict him. Participants presented with evidence from fingerprints, handwriting, or a lie detector were substantially less willing to convict the accused.

Id.

in favor of the greater use of hair evidence. Admittedly, some hair analysis is subjective in nature, as hair analysts have conceded.[268] But that concession holds true precisely because, in most instances, the analyst uses conventional microscopy.[269] The standards for evaluating a microscopic hair examination are more subjective and less exact than the guidelines employed in some of the other available techniques.[270] If the analyst gives vague "similarity" testimony based on microscopic examination, the lay jurors will have difficulty deciding how much weight to attach to the testimony. In contrast, if the analyst employs the techniques for determining the hair source's blood type,[271] enzymes,[272] or proteins,[273] the analyst can cite the population frequency statistics for the grouping. This testimony is much more objective, and the jury can readily decide how much significance to attribute to the testimony. Therefore, the remedy for the subjectivity of much hair analysis is not less reliance on hair evidence. Reducing that reliance would increase our dependence on lay eyewitness testimony, which itself is flawed by subjective factors that cannot be quantified.[274] The proper antidote is more extensive use of hair analysis—specifically, greater resort to the more objective analytic techniques such as blood grouping from hair samples.

Just as the subjectivity attack on hair analysis converts into an argument for greater use of hair evidence, the revelations in the Laboratory Proficiency Testing Program bolster the case for more extensive use of hair analysis. Almost all the laboratories participating in the Program used only conventional microscopy.[275] In that light, the high error rates reported in the Program were expectable. The Federal Bureau of Investigation (FBI) has voiced doubts about the accuracy of microscopic examinations.[276] In particular, the FBI is skeptical about the reliability of sex determinations based exclusively on conventional microscopy.[277] In contrast to conventional microscopy, the X-chromatin and Y-chromosome tests are extremely accurate.[278] As previously noted, there was not a single false positive in one Y-chromosome experiment.[279] Thus, greater use of more sophisticated hair analysis techniques is likely to reduce the incidence of error in fact-finding.

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[268] *See* note 242 *supra*.

[269] *See* note 234 *supra*.

[270] Lewis, *The Element of Subjectivity in Interpreting Instrumental Test Results*, in Imwinkelried, *supra* note 28, at 414-16.

[271] *See* text accompanying note 140 *supra*.

[272] *See* text accompanying note 141 *supra*.

[273] *See* text accompanying note 142 *supra*.

[274] *See* text accompanying notes 260-66 *supra*.

[275] J. PETERSON, E. FABRICANT & K. FIELD, THE CRIME LABORATORY PROFICIENCY TESTING RESEARCH PROGRAM 172 (1978).

[276] *Don't Miss a Hair*, *supra* note 8, at 4.

[277] *Id.*

[278] *See* text accompanying notes 81-91 *supra*.

[279] *See* note 91 *supra*.

IV. Conclusion

In the final analysis, the attacks on hair analysis are arguments against the misuse and underemployment of hair evidence. It is true that much of the hair testimony admitted in court suffers from the flaw of subjectivity, but the underemployment of hair analysis is the root cause of that flaw. Criminal attorneys underemploy hair analysis in the sense that they have been content with less sophisticated methods of analysis which permit only vague conclusions of similarity and consistency. Likewise, there is merit in the critics' assertion that there is a substantial margin of error in the type of hair analysis currently used in the courtroom. However, again the underemployment of hair analysis is a cause of that error margin. Criminal practitioners also underemploy hair analysis in the sense that they have been content to use less reliable techniques. At least for making determinations such as the sex of the human hair source, conventional microscopy is less trustworthy than other analytic techniques that have been neglected to date.

Pope's memorable quotation from the *Essay on Criticism* applies aptly to the use of hair evidence in criminal cases. In the past, both prosecutors and defense counsel unfortunately have been satisfied with too "little learning" about the state of the art of hair examination. Their cursory, "shallow draughts" have resulted in an undesirable reliance on subjective, error-prone techniques. But the cure is not retreating from the use of hair analysis; that cure would be worse than the disease. The probable effect of decreased use of hair analysis would be increased reliance on lay eyewitness testimony—which is highly subjective and notoriously untrustworthy. The paradox is that the best cure is to use hair analysis more extensively. Specifically, prosecutors must make greater use of the techniques for making sex and blood grouping determinations. We must take Pope's advice to heart and "drink deep" of the modern forensic learning about hair analysis.