CHAPTER 13

Forensic Science and Identification

§13.1 THE FORENSIC SCIENCES

With the exception of forensic medicine, forensic science is largely a twentieth-century innovation. "By 1915 only three New England states and the city of New York had replaced their coroner systems with a more progressive medical examiner system. The first operational crime laboratory in the country was not established until 1923 in Los Angeles, followed by the Scientific Crime Detection Laboratory at Northwestern University in 1929, and the Federal Bureau of Investigation laboratory in 1932. . . . England did not create a forensic laboratory until 1935."[1] Even

§13.1 [1] John I. Thornton, Uses and Abuses of Forensic Science, 69 A.B.A. J. 288, 291 (1983). Forensic medicine has a much longer history. In China, the elements of toxicology were recognized long ago, and the *Materia Medica* of 3000 B.C. included information on aconite, arsenic and opium. *Hsi Yuan Lu* (Instructions to Coroners) dealt with practically every topic in forensic medicine. This classic text first appeared in 1250 A.D. and was amended and reprinted up to the nineteenth century. M.S. Salgado, Forensic Medicine in the Indo-Pacific Region: History and Current Practice of Forensic Medicine, 36 Forensic Sci. Int'l 3, 3 (1988). Medical testimony in English criminal cases in the twenty-first century, the archaic coroner system still is common, and the infrastructure of forensic science remains weak in important respects, including a lack of standardization, regulation, certification, basic research, and independent research funding.[2]

In its broadest form, forensic science consists of "any science used in the resolution of legal conflicts."[3] By this definition, virtually every science is forensic science, for such diverse disciplines as anthropology, chemistry, ecology, economics, entomology, epidemiology, genetics, geology, odontology, pathology, physics, psychiatry, psychology, statistics, and toxicology have been used to help resolve contested facts in litigation. In a narrower sense, however, forensic science refers to those specialities that study factual issues that are uniquely or predominantly of interest to the legal system.[4] For example, forensic pathology, which is an adaptation of the pre-existing discipline of pathology, includes techniques to determine the time of death[5] — a problem that does not arise in many other medical contexts. The field of criminalistics, which is a novel synthesis of natural and physical sciences, "is concerned with the analysis, identification, and interpretation of hairs and fibers; bloodstains and seminal stains; firearms evidence; soil, glass and paint classifications; toolmarks; arson accelerants;

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extends back into the Middle Ages, but "[n]ews of important advances in Italy, Germany, France and other countries crossed the Channel only, it seems, very slowly. Pathology, a sister science, did not even begin to bloom in Britain until the late 1700s. . . . For far too long the average expert medical witness in an English courtroom or inquest chamber was a busy surgeon, obliged to mount the witness box only a few times at most in his career and ill prepared for the experience." Thomas Forbes, Surgeons at the Bailey: English Forensic Medicine to 1878, 3 (1985).

[2] National Research Council Committee on Identifying the Needs of the Forensic Science Community, Strengthening Forensic Science in the United States: A Path Forward (2009) [NRC Forensic Science Report] (discussed *infra* §13.2.1).

[3] Thornton, *supra* note 1, at 289. "The word 'forensic' comes from the Latin *forensus*, meaning 'of the forum.' The ancient Roman forum was the site of debates concerning governmental issues, but it also was the courthouse, where trials were held." Id.

[4] The American Academy of Forensic Sciences, the largest professional forensic society in the world, recognizes the following scientific disciplines: forensic pathology, forensic toxicology, forensic anthropology, forensic odontology, forensic psychiatry, questioned documents, forensic engineering, and criminalistics. Id. The scientists in the disciplines enumerated by the American and British Academies of Forensic Science tend to share certain distinctive professional attitudes and goals. They think of themselves not just as scientists who sometimes have information to contribute in court, but as scientists whose work always is connected with the legal system. They strive to make their disciplines more useful and more relevant to the administration of justice. "All of these disciplines have a unifying theme — the introduction of science into the legal process in an objective and impartial manner . . . ." Id. at 291.

[5] Jessica Snyder Sachs, Corpse: Nature, Forensics, and the Struggle to Pinpoint Time of Death (2002).

explosives; serial number restoration; and virtually everything else that does not fit tidily into one of the other disciplines."[6]

As a highly applied science, forensic science often borrows well-established scientific instruments and methods. The polygraph, for example, clearly is a valid indicator of physiologic stress, but whether it a valid indicator of deception is far less obvious.[7] Neutron activation analysis identifies the elements composing substances such as paint, but does it permit the forensic scientist to identify a paint chip as having originated from a specific source?[8] Inductively coupled plasma-optical emission spectroscopy determines the concentrations of elements in bullet lead, but research hardly supports testimony that two bullets originated from the same manufacturer, the same melt of lead, or the same box of bullets.[9] The

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[6] Thornton, *supra* note 1, at 290–291. Because criminalistics "represents what remains other than pathology, odontology, toxicology, and the other forensic subspecialties," "its origins cannot be attributed to any single parent discipline." Id. at 291. For surveys of each type of forensic identification, see 1 & 2 Paul C. Giannelli & Edward J. Imwinkelried, Scientific Evidence (4th ed. 2007); NRC Forensic Science Report, *supra* note 2; John I. Thornton & Joseph L. Peterson, "The General Assumptions and Rationale of Forensic Identification: Scientific Issues — Introduction," *in* 4 Modern Scientific Evidence: The Law and Science of Expert Testimony §§30:44 to 30:56 (David L. Faigman et al. eds., 2009–2010 ed.).

[7] *See* 5 Modern Scientific Evidence: The Law and Science of Expert Testimony §40 (David L. Faigman et al. eds., 2009-2010 ed.); Giannelli & Imwinkelried, *supra* note 6, ch. 8; National Research Council Committee to Review the Scientific Evidence on the Polygraph, The Polygraph and Lie Detection (2003).

[8] *See* Dennis Karjala, Note, The Evidentiary Use of Neutron Activation Analysis, 59 Cal. L. Rev. 997 (1971).

[9] National Research Council Committee on Scientific Assessment of Bullet Lead Elemental Composition Comparison, Forensic Analysis: Weighing Bullet Lead Evidence (2004); David H. Kaye, The Current State of Bullet-Lead Evidence, 46 Jurimetrics J. 99 (2006). Typically, courts failed to recognize the depth of the deficiencies in the inference from "matching" elemental composition to "same source." *E.g.*, United States v. Davis, 103 F.3d 660 (8th Cir.1996); Ragland v. Commonwealth, No. 2002-SC-0388-MR, 2004 WL 2623926 (Ky. Nov. 18, 2004), *reheard*, 191 S.W.3d 569 (Ky. 2006); State v. Noel, 157 N.J. 141, 723 A.2d 602 (N.J.1999); Commonwealth v. Fisher, 870 A.2d 864, 870–872 (Pa. 2005). In an unpublished opinion, however, a federal district court held that the lack of empirical support for this inference renders testimony about the composition of a bullet inadmissible under *Daubert*. United States v. Mikos, No. 02 CR 137, 2003 WL 22922197 (N.D. Ill. Dec. 9, 2003). Likewise, in Ragland v. Commonwealth, 191 S.W.3d 569 (Ky. 2006), the Kentucky Supreme Court revised its initial opinion to hold that CBLA does not satisfy *Daubert*; *see also* Clemons v. State, 896 A.2d 1059, 1079 (Md. 2006) ("CBLA does not satisfy the requirement under the [*Frye*] test for the admissibility of scientific expert testimony because several fundamental assumptions underlying the process are not generally accepted by the scientific community"); *cf.* Smith v. State, 23 So. 3d 1277 (Fla. Dist. Ct. App. 2010) (dismissal of motion for post-conviction relief without a hearing was improper); State v. Behn, 868 A.2d 329 (N.J. Super. Ct. App. Div. 2005) (granting post-conviction relief to allow a more effective challenge to be mounted to FBI testimony of matching compositions of bullets).

validity and reliability of these quintessentially forensic methods should not be taken for granted.[10] This caution applies to methods that have become established in the field and in the courtroom as well as to new applications.[11]

In this book, we cannot hope to examine all fields of forensic science in detail. As with science in general, many theories and methods are in flux, and few lawyers are prepared to recognize the strengths or uncover the inadequacies in scientific work. For such purposes, consultation with an expert and study of some of the scientific literature are indispensable. Consequently, the chapters on forensic science do not pretend to explain the workings of the various forensic sciences and all of the associated statutes and cases. In keeping with the more general theme of this book, they analyze legal doctrine and the reasoning that informs this doctrine. The next section indicates how the fact that some analytic techniques are used only in connection with criminal investigation or litigation affects the application of the usual rules for the admissibility of expert testimony. The remainder of this chapter and the next two chapters then examine the law that has developed in response to a topic that cuts across many subfields of criminalistics — crime-scene evidence and individualization.[12]

§13.2 THE ADMISSIBILITY OF "FORENSICS-ONLY" SCIENCE

Most research in forensic science is conducted with an eye toward possible courtroom applications. Indeed, some methods are developed for specific litigation,[1] and many of the forensic scientist's procedures have little or no use in other professional or commercial activities. In this respect, a good deal of forensic science testimony is unlike testimony from, say, an orthopedic surgeon about the nature or extent of a fracture as ascertained by personal and radiological examinations. That testimony rests on procedures routinely and widely used for purposes other than resolving legal disputes. Consequently, the success-in-the-marketplace model for

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[10] *See, e.g.*, Thornton & Peterson, *supra* note 6.

[11] *See supra* Chapter 9.

[12] Some of the material on this topic is adapted from David H. Kaye & George S. Sensabaugh, "Reference Guide on DNA Evidence," *in* Reference Manual on Scientific Evidence (Federal Judicial Center ed., 2d ed. 2000).

§13.2 [1] *E.g.*, Coppolino v. State, 223 So. 2d 68 (Fla. Dist. Ct. App. 1968) (toxicologist developed a test for the presence of succinylcholine chloride in a corpse to determine whether the defendant had injected a lethal dose of this anesthetic into his wife).

expert evidence[2] frequently fails to capture the reality of evidence from forensic scientists. The "commercial marketplace" model presumes expertise from the fact that "a person could make a living selling his knowledge in the marketplace. . . . In effect, the marketplace determined whether valid knowledge existed by endowing it with commercial value."[3] The theory of the test was that "[k]nowledge that proved valuable [in the market] could hardly be without worth in a courtroom. What was good enough for the marketplace was good enough for the courtroom."[4] However, if the same scientific or technical procedure is not used in the same manner in other fields, such as medical care or engineering, then the proponent of the evidence cannot draw strength from the fact that the technique has proved itself in those other domains. Just as the rationale of the business-records exception to the hearsay rule hardly applies to records generated only for use in litigation,[5] the general-acceptance standard for scientific evidence promulgated in *Frye v. United States*[6] is problematic when applied to "forensics-only" science. In both situations, use of the evidence in the world outside the courtroom fails to supply an independent indicium of trustworthiness.

To admit "forensics-only" science, courts have followed two basic strategies. Some have been willing to narrow the community in which "general acceptance" is necessary to forensic scientists themselves,[7] while others have adopted criteria for admissibility to supplement or substitute for general acceptance in the scientific community.[8] Roughly speaking, the latter approach permits courts to inquire into the validity of the technique as revealed by the extent to which it has been tested and exposed to the critical review of forensic and other scientists.[9]

This section explains why there should be no impenetrable barrier to "forensics-only" science and why the inquiry should extend beyond "general acceptance." We first consider a set of cases in which courts have

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[2] *See* David L. Faigman et al., Check Your Crystal Ball at the Courthouse Door, Please: Exploring the Past, Understanding the Present, and Worrying About the Future of Scientific Evidence, 15 Cardozo L. Rev. 1799, 1804–1805 (1994). The notion that a "commercial marketplace test" was a forerunner to the general acceptance standard of Frye v. United States, 293 F. 1013 (D.C. Cir. 1923), is oversimplified (*see supra* §6.2 note 5), but reliance on a methodology in important activities outside the justice system often is an important consideration under both *Frye* and *Daubert*. *See supra* Chapters 6, 7.

[3] Faigman et al., *supra* note 2. The authors note that "[t]his is not a point that courts made explicitly," but they argue that "it seems to be implicit in the courts' determinations of who was 'qualified.'" Id.

[4] Id. at 1804–1805.

[5] *See* Palmer v. Hoffman, 318 U.S. 109 (1943).

[6] 293 F. 1013 (D.C. Cir. 1923).

[7] *See supra* Chapter 6.

[8] *See supra* Chapter 7.

[9] Id.

allowed general acceptance in forensic science to establish the trustworthiness of scientific evidence and indicate the weakness of this approach. We suggest that "general acceptance" in forensic science is not a *sufficient* condition for admissibility. We then consider cases that respond to "forensics-only" science not by narrowing the zone of acceptance to the forensic scientists themselves, but by inquiring directly into the grounds for the adoption of the particular methodology in the field. We suggest that this is preferable to inferring scientific soundness from general acceptance among forensic scientists. In other words, we argue that "general acceptance" in forensic science is neither a sufficient nor a necessary condition for admissibility.

§13.2.1 "General Acceptance" in Forensic Science Should Not Be a Sufficient Condition for Admissibility

Cases on the admissibility of certain tests of blood proteins illustrate the judicial strategy of finding "general acceptance" in the forensic science community alone — and its shortcomings.[10] Blood plasma, the fluid component of blood, contains proteins that reflect genetic variations among human beings. The different proteins can be isolated by a technique called electrophoresis, in which the proteins are placed at the top of a rectangular slab of a gelatin-like substance (a "gel"). An electric field is applied, and the protein molecules are pulled differing distances down through the gel according to their electric charge and size. After a suitable time, the positions of the resulting bands of proteins are determined. This gel electrophoresis is a standard technique in biochemistry. Because it is used in so many areas of research and analysis, courts can be confident that it is capable of yielding valid results under the usual laboratory conditions.[11]

In the late 1970s scientists adapted the general principles to the needs of criminal investigators. They devised a thin gel that permitted them to analyze simultaneously three systems of these genetic markers, providing as much information as possible from a small stain. But outside the field of forensic science, no one used this thin-gel multisystem to type aged, dried, and sometimes contaminated blood stains. The external indicium of validity therefore was lacking, and in the 1980s controversy over the admissibility of this adaptation of electrophoresis flared.[12] It was

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[10] *See* David H. Kaye, The Double Helix and the Law of Evidence 13–18 (2010).

[11] An epynonymous scientific periodical is devoted to technical reports about the technology.

[12] *See* People v. Brown, 726 P.2d 516 (Cal. 1985) (inadequate showing that *Frye* test satisfied), *rev'd on other grounds*, 479 U.S. 538 (1985); People v. Harbold, 464 N.E.2d 734, 746 (Ill. App. Ct. 1984) ("There is some dispute among scientists as to the

suggested that the multisystem test in particular could produce erroneous results[13] and that the application of electrophoresis generally to samples from crime scenes had not been adequately validated.[14]

Almost all appellate courts that encountered challenges to electrophoretic identifications concluded that both the multisystem and the more widely used electrophoretic procedures were scientifically accepted and that the findings could be admitted into evidence. They achieved this result either by failing to differentiate between the widely used electrophoretic procedures and the multisystem test[15] or by recognizing the distinction but not demanding acceptance of thin-gel multisystem testing outside the field of forensic science.[16] The most notable — and telling — exception to this nearly solid wall of precedent is *People v. Young*,[17] in which the Michigan Supreme Court failed to find sufficient proof of

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accuracy of results derived from electrophoretic testing of dried blood stains."); People v. Young, 340 N.W.2d 805, 814 (Mich. 1983); Randolph N. Jonakait, Will Blood Tell? Genetic Markers in Criminal Cases, 31 Emory L.J. 833 (1982); Michael R. Flaherty, Annotation, Admissibility, in Criminal Cases, of Evidence of Electrophoresis of Dried Evidentiary Bloodstains, 66 A.L.R.4th 588 (1988).

[13] *E.g.*, People v. Gistover, 472 N.W.2d 27, 30 (Mich. Ct. App. 1991) (referring to "concern over the reliability of the Wraxall thin-gel multisystem stemm[ing] from the lack of independently conducted reliability studies in light of the criticism . . . that the filter used in testing EsD molecules has the unintended effect of compromising the analysis of the PGM and GLO molecules").

[14] *See, e.g.*, People v. Reilly, 242 Cal. Rptr. 496 (Ct. App. 1987):

> Defendant thus does not maintain that electrophoresis as a method in general lacks acceptance or reliability. His argument is that the method is not accepted as applied to "dried, aged evidence samples taken from whatever surface they may fall upon at the scene of a crime. . . ." [H]is concern is over whether serologists who apply the tests can adequately account for the effects of blood sample deterioration and crime scene contaminants.

Id. at 502.

[15] *E.g.*, State v. Beaty, 762 P.2d 519 (Ariz. 1988) (analysis ends with the undiscriminating observation that "PGM or blood grouping tests are a well-recognized and admissible means for identification of blood and semen samples"); People v. Thomas, 562 N.E.2d 396 (Ill. App. Ct. 1990) (taking judicial notice of unspecified forms of electrophoresis among forensic scientists).

[16] *E.g.*, People v. Lopez, 593 N.E.2d 647, 656 (Ill. App. Ct. 1992) ("the trial court can take judicial notice that electrophoresis is generally accepted by forensic scientists as a reliable method of detecting genetic markers in dried blood"); State v. Fenney, 448 N.W.2d 54 (Minn. 1989) ("taking forensics as the relevant field," electrophoresis of dried blood is generally accepted and isoelectric focusing results are admissible); State v. Dirk, 364 N.W.2d 117 (S.D. 1985) (*Frye* test met by expert's testimony that forensic laboratories use the technique); *cf.* Commonwealth v. Gomes, 526 N.E.2d 1270 (Mass. 1988) (relying on other opinions that "have specifically held that the multisystem method is generally accepted in the relevant scientific community").

[17] 391 N.W.2d 270 (Mich. 1986).

acceptance of the multisystem test among "scientists not working for a police agency."[18]

Constricting the scientific community to forensic scientists is not an adequate solution. As a formal matter, it resolves the problem of applying the general acceptance test to "forensics-only" evidence, but this limited acceptance does not necessarily demonstrate that the scientific theories and techniques can be relied on in court. The premise that the theory and methodology have proved themselves in important areas outside the criminal justice system carries no weight, and if crime laboratories adopt a method before it has been adequately validated, this version of "general acceptance" will not detect the gap in the scientific foundation for the expert testimony.[19]

This scenario is not fanciful. Although forensic science research is advancing, the field is burdened with "generally accepted" tests or procedures later shown to be invalid or yet to be fully validated. In recent years, the authors of legal treatises and journals have complained bitterly about the lack of regulation of forensic laboratories, the absence of rigorous proficiency testing, and the dearth of basic research that would demonstrate the alleged ability of fingerprint, toolmark, and other analysts to identify traces from one person or object to the exclusion of all others in the world.[20] They have written dismissively of "nonscience forensic sciences"

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[18] Id. at 271; *see also* People v. Brown, 726 P.2d 516 (Cal. 1985) (questionable whether testimony of police chemist that method for identifying proteins in dried blood was "an accepted practice in the field of forensic chemistry and . . . utilized by large numbers of law enforcement agencies" would have been established "acceptance by impartial scientists in field of forensic chemistry"), *rev'd on other grounds*, California v. Brown, 479 U.S. 538 (1987); Kaye, *supra* note 10, ch.1.

[19] For this reason, the many opinions emphasizing the century-old acceptance of fingerprinting in law enforcement and trials rest on a tenuous foundation. *See, e.g.*, United States. v. Crisp, 324 F.3d 261, 276–277 (4th Cir. 2003) (dissenting opinion) ("Fingerprint identification's long history of use does not by itself support the decision to admit it. Courts began admitting fingerprint evidence early last century with relatively little scrutiny, and later courts, relying on precedent, simply followed along. To put it bluntly, the precedent of prior admission, rather than exacting scientific scrutiny, led to its universal acceptance.").

[20] A small sample of this literature includes 4 & 5 Modern Scientific Evidence: The Law and Science of Expert Testimony (David L. Faigman et al. eds. 2009–2010 ed.); Simon A. Cole, Is Fingerprint Identification Valid? Rhetorics of Reliability in Fingerprint Proponents' Discourse, 28 L. & Pol'y 109 (2006); Craig M. Cooley, Reforming the Forensic Community to Avert the Ultimate Injustice, 15 Stan. L. & Pol'y Rev. 318 (2004); Paul C. Giannelli, Wrongful Convictions and Forensic Science: The Need to Regulate Crime Labs, 86 N.C. L. Rev. 163 (2007); Jennifer L. Mnookin, The Validity of Latent Fingerprint Identification: Confessions of a Fingerprinting Moderate, Law, Probability & Risk 127 (2008); Michael J. Saks & Jonathan J. Koehler, The Coming Paradigm Shift in Forensic Identification Science, 309 Science 892 (2005).

that "have little or no basis in actual science," and they have implored courts to exclude testimony pending better research showing that analysts can live up to their claims.[21] Despite the lack of rigorous validation of the comparison of latent fingerprints,[22] fingerprint analysts have not been quick to subject their claims of error-free individualization to meaningful scrutiny.[23] Despite widespread judicial acceptance of bite mark identification, the ability of odontologists to identify the one set of teeth that left a given bite mark has been described as illusory.[24] In 2009, a committee of the National Research Council released a survey of the scientific status of these and other forensic science methods that gave credence to many of these complaints.[25] Chapter 5 of the report describes significant limitations on the current knowledge in the fields of friction ridge analysis;[26] shoeprints, tire tracks, and other impression evidence;[27] toolmark and firearms identification;[28] hair and fiber comparisons;[29] questioned document

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[21] *E.g.*, Simon A. Cole, Does "Yes" Really Mean Yes? The Attempt to Close Debate on the Admissibility of Fingerprint Testimony, 45 Jurimetrics J. 449 (2005); Lyn Haber & Ralph Norman Haber, Experiential or Scientific Expertise, 7 Law, Probability & Risk 143 (2008); D. Michael Risinger & Michael J. Saks, Science and Nonscience in the Courts: *Daubert* Meets Handwriting Identification Expertise, 82 Iowa L. Rev. 21 (1996); Adina Schwartz, A Systemic Challenge to the Reliability and Admissibility of Firearms and Toolmark Identification, 6 Colum. Sci. & Tech. L. Rev. 2 (2004–2005) ("all firearms and toolmark identifications should be excluded until adequate statistical empirical foundations and proficiency testing are developed for the field.").

[22] *E.g.*, Lyn Haber & Ralph Norman Haber, Scientific Validation of Fingerprint Evidence Under *Daubert*, 7 Law, Probability & Risk 87 (2008).

[23] Mnookin, *supra* note 20.

[24] *E.g.*, Erica Beecher-Monas, Reality Bites: The Illusion of Science in Bite-mark Evidence, 30 Cardozo L. Rev. 1369 (2009); I.A. Pretty & D. Sweet, The Scientific Basis for Human Bitemark Analyses — A Critical Review, 41 Sci. & Just. 85 (2001).

[25] National Research Council Committee on Identifying the Needs of the Forensic Science Community, Strengthening Forensic Science in the United States: A Path Forward (2009) [NRC Forensic Science Report].

[26] "None of these variabilities — of features across a population of fingers or of repeated impressions left by the same finger — has been characterized, quantified, or compared." Id. at 144.

[27] "[C]ritical questions that should be addressed include the persistence of individual characteristics, the rarity of certain characteristic types, and the appropriate statistical standards to apply to the significance of individual characteristics." Id. at 150.

[28] "Because not enough is known about the variabilities among individual tools and guns, we are not able to specify how many points of similarity are necessary for a given level of confidence in the result. Sufficient studies have not been done to understand the reliability and repeatability of the methods." Id. at 154.

[29] "No scientifically accepted statistics exist about the frequency with which particular characteristics of hair are distributed in the population. There appear to be no uniform standards on the number of features on which hairs must agree before an examiner may declare a 'match.'" Id. at 160.

examination;[30] the analysis of paint and coatings;[31] explosives and fire debris;[32] forensic odontology;[33] and bloodstain patterns.[34] Proposing an overhaul of the system of forensic science as currently practiced, the committee reported that:

> The forensic science disciplines exhibit wide variability with regard to techniques, methodologies, reliability, level of error, research, general acceptability, and published material. . . . Many of the processes used in the forensic science disciplines are . . . not based on a body of knowledge that recognizes the underlying limitations of the scientific principles and methodologies for problem solving and discovery. . . . [S]ome of these activities [encompassed by the term "forensic science"] might not have a well developed research base, are not informed by scientific knowledge, or are not developed within the culture of science.[35]

A co-chair of the committee described the report as a "call for *real science* to support the forensic disciplines"[36] and reiterated the committee's concern over "the paucity of scientific research to confirm the validity and reliability of the forensic disciplines"[37] and the institutional and organizational problems with the delivery of forensic science.[38]

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[30] "The scientific basis for handwriting comparisons needs to be strengthened. Recent studies have increased our understanding of the individuality and consistency of handwriting and computer studies and suggest that there may be a scientific basis for handwriting comparison, at least in the absence of intentional obfuscation or forgery." Id. at 166.

[31] "As is the case with fiber evidence, analysis of paints and coatings is based on a solid foundation of chemistry to enable class identification. . . . However, the community has not defined precise criteria for determining whether two samples come from a common source class." Id. at 170.

[32] "[M]any of the rules of thumb that are typically assumed to indicate that an accelerant was used (e.g., 'alligatoring' of wood, specific char patterns) have been shown not to be true." Id. at 173.

[33] Id. at 176 (pointing to "a lack of valid evidence to support many of the assumptions made by forensic dentists during bite mark comparisons" and noting that "[a]lthough the majority of forensic odontologists are satisfied that bite marks can demonstrate sufficient detail for positive identification, no scientific studies support this assessment, and no large population studies have been conducted. In numerous instances, experts diverge widely in their evaluations of the same bite mark evidence . . . .") (notes omitted).

[34] "[S]ome experts extrapolate far beyond what can be supported." Id. at 178.

[35] Id. at 38–39.

[36] Harry T. Edwards, Solving the Problems that Plague the Forensic Science Community, 50 Jurimetrics J. 5, 13 (2009) (emphasis added).

[37] Id. at 7.

[38] Id. On the prospects for proposed institutional reforms, see David H. Kaye, The Good, the Bad, and the Ugly: The NRC Report on Strengthening Forensic Science in America, 50 Sci. & Just. 8 (2010); William C. Thompson, The National Research

This committee also suggested that by and large, the courts have failed to perceive the gap between optimistic theory and hard proof, and they have accepted remarkably weak forms of validation.[39] That history reinforces a point emphasized in Chapter 7. Courts can apply both *Frye* and *Daubert* flaccidly or firmly. Thus, rejecting general acceptance in the forensic science community as determinative, which is the core proposition adopted in *Daubert*, does not guarantee correct outcomes in all cases. However, as the next subsection explains, it does make it somewhat easier for courts to exercise an effective level of review for forensic science evidence.

§13.2.2 "General Acceptance" in Forensic Science Should Not Be a Necessary Condition for Admissibility

Although the type of general acceptance that provides a basis for the transition from other fields of endeavor to the law cannot be established merely by the opinions of law-enforcement authorities, the acceptance of a technique in the law-enforcement community certainly could rest on a scientifically sound foundation. "Forensics-only" methods can be validated, and the validation studies can be published and replicated. Aided by suitable experts, courts can look to the body of research itself to decide whether the legitimate questions about these methods have been dispelled by such research. This inquiry can substitute for the external indicium of reliability that comes from the similar use of a scientific procedure in other fields of science, medicine, or industry. Thus, even *Young* did not hold that thin-gel electrophoresis must remain inadmissible until it finds applications in fields other than criminalistics. The crux of the court's concern revolved around the lack of a research base with which to respond to reasonable critics or skeptics:

> The scientific tradition expects independent verification of new procedures. When other scientists analyze and repeat the tests, they counteract the dangers of biased reporting. . . . No independently conducted verification studies have been undertaken.[40]

Council's Plan to Strengthen Forensic Science: Does the Path Forward Run Through the Courts?, 50 Jurimetrics J. 35 (2009).

[39] NRC Forensic Science Report, *supra* note 25, at 11–12 & 108–09 ("'[T]he undeniable reality is that the community of forensic science professionals has not done nearly as much as it reasonably could have done to establish either the validity of its approach or the accuracy of its practitioners' conclusions,' and the courts have been 'utterly ineffective' in addressing this problem.") (quoting Mnookin, *supra* note 20, at 134); *see also* Joseph Sanders, Applying *Daubert* Inconsistently?: Proof of Individual Causation in Toxic Tort and Forensic Cases, 75 Brooklyn L. Rev. 1367 (2010); Thompson, *supra* note 38 (supplementing the committee's explanation for the lax application of *Daubert*).

[40] 391 N.W.2d at 283.

Many courts, perhaps realizing that a major premise of the general-acceptance test cannot be satisfied by narrowing the relevant discipline to forensic science alone, effectively abandoned the test. For a time, some courts did so surreptitiously, pretending that they were finding general acceptance. For example, in *United States v. Franks*,[41] the Court of Appeals for the Sixth Circuit resorted to an obvious sleight of hand to conclude that the forensics-only use of frequency spectrograms of human voices to identify speakers was generally accepted. That court wrote: "We deem general acceptance as being nearly synonymous with reliability. If a scientific process is reliable, or sufficiently accurate, courts may also deem it 'generally accepted.'"[42]

Other courts have responded to forensics-only evidence by expressly repudiating *Frye* to allow a direct inquiry into the soundness of the forensic science in question.[43] This more forthright approach is preferable. The real question is whether the scientific technique is trustworthy enough to be allowed as proof, and the courts should address this question directly. Particularly with forensics-only science, general acceptance is *not* synonymous with reliability and validity. General use in law enforcement is neither a necessary nor a sufficient condition for admissibility. It is simply one factor that should be considered along with others. General acceptance of forensics-only science by forensic scientists or a "technical community" should be neither ignored nor overvalued. It is less impressive than general acceptance in a broader scientific community, but it is not without significance. Combining the degree of acceptance with a direct inquiry into the various other indicia of trustworthiness for this type of testimony is most likely to produce decisions separating premature forensic methods from those that are ready for their days in court.[44]

The most powerful counterargument is that judges usually lack the training and understanding of science to filter valid from dubious forensic science. If this more pessimistic view were adopted, however, a choice would have to be made between two alternatives. On the one hand, judges might defer to the forensic science community as to which forensics-only methods work well enough to be relied on in court — the strategy criticized in the previous section. On the other hand, they could exclude the testimony for lack of acceptance in the broader scientific community even

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[41] 511 F.2d 25 (6th Cir. 1975).

[42] Id. at 33 n.12 (quoted in United States v. Distler, 671 F.2d 954, 961 (9th Cir. 1981)). Whether voice spectrograms offer a sufficiently valid basis for speaker identification is doubtful. *See, e.g.*, 1 McCormick on Evidence §207 (Kenneth Broun ed., 6th ed. 2006). Nonetheless, "no consistent or coherent judicial view can be discerned." 5 Modern Scientific Evidence, *supra* note 20, §38:1, at 98.

[43] *See supra* §7.3.2(d).

[44] *See supra* Chapter 7.

when forensic scientists — the only scientists who normally would study and rely on the method — have done so and are satisfied with it.

As we have seen, neither approach is very palatable. The former is prone to the admission of dubious science, and the latter can exclude valid science. However, a variation on the more stringent general-acceptance test is preferable. Courts that insist on general acceptance should allow ad hoc study by scientists from related disciplines to substitute for the actual use of the forensic methods or applications in these disciplines. Instead of waiting for acceptance in the commercial or research "markets" of techniques or applications that have no place in those markets, courts should allow the proponents of the methods to induce a wider research community to examine and approve of them. This would provide national law-enforcement authorities with an incentive to invest in independent studies and reviews by researchers outside the law-enforcement community. Thus, when faced with criticisms of forensics-only techniques from highly respected scientists and court opinions excluding laboratory results, the FBI has helped sponsor reviews by the National Academy of Science. Voiceprintingreceived a largely negative evaluation from a study committee,[45] while DNA profiling garnered two largely positive reviews.[46] A method of associating bullets with one another by comparing the concentrations of elements in each bullet was seen as incapable of supporting anything but the vaguest testimony.[47] Such independent evaluations can fill

[45] National Research Council Committee on Evaluation of Sound Spectrograms, On the Theory and Practice of Voice Identification 4–5 (1979) ("the assumption that intraspeaker variability is less than . . . interspeaker variability . . . is not adequately supported by scientific theory and data").

[46] National Research Council Committee on DNA Technology in Forensic Science, DNA Technology in Forensic Science x (1992) ("We recommend that the use of DNA analysis for forensic purposes, including the resolution of both civil and criminal cases, be continued while the improvements and changes suggested in this report are being made"); National Research Council Committee on DNA Forensic Science: An Update, The Evaluation of Forensic DNA Evidence 10 (1996) ("DNA analysis, when properly carried out and interpreted, is a very powerful tool."). In the interest of full disclosure, it should be noted that the author of this chapter participated in writing the second NRC report; however, the views presented in that report are those of the full committee.

[47] National Research Council Committee on Scientific Assessment of Bullet Lead Elemental Composition Comparison, Forensic Analysis: Weighing Bullet Lead Evidence (2004). Initially, the FBI responded by insisting that "[t]he basis of bullet lead compositional analysis is supported by approximately 50 peer-reviewed articles," that the technique continues to be supported by "[p]ublished research and validation studies," and that "[t]he science has continually withstood legal challenges in federal, state, and local criminal courts." FBI National Press Office, National Academy Releases FBI-commissioned study on Bullet Lead Analysis, Feb. 10, 2004. The next year the FBI discontinued the use of the procedure. Charles Piller, FBI Abandons Controversial Bullet-Matching Technique, L.A. Times, Sept. 2, 2005.

the gap in the proof of general acceptance created by the lack of use of the technique outside the world of forensics.[48] The independent vetting of forensic methods, however, still could result in the loss of methods that are only slightly superior to more established techniques or useful only in small numbers of cases. In these situations, the proponent of the evidence may find the cost of external review prohibitive.

§13.3 TRACE EVIDENCE AND IDENTIFICATION

An important task in criminalistics is the study of physical traces. Frequently the perpetrator has left some trace evidence — fingerprints, hairs, bite marks, bloodstains, saliva, semen, handwriting, tool marks, paint chips, or a tape-recorded voice.[1] Sometimes traces from a victim or materials at the scene of the crime can be found on the perpetrator or his possessions. Pollen, soil, seeds, glass fragments, fibers, a victim's blood, a scent, or some of the items listed above are found on a suspect, his clothing, vehicle, or another item with which he has had contact. The objective of the scientific investigation is to link the perpetrator of a crime to the scene or the victim through this type of circumstantial evidence.[2] The law and the logic

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[48] The NRC report on voice identification, *supra* note 45, has had less impact on the admissibility of voice spectrograms than one might have expected. *See, e.g.*, 5 Modern Scientific Evidence, *supra* note 20, §38:1. The more recent DNA reports were more prominent in subsequent litigation and in opinions on the admissibility of DNA profiling. *See* Kaye, *supra* note 10. The difference may be attributable to the increased familiarity in the 1990s of parts of the legal profession with the scientific establishment.

§13.3 [1] Criminalists usually define "trace evidence" more narrowly, to encompass only "small, often microscopic fragments of various types of material that transfer between people, places, and objects, and persist there for as time." Max M. Houck, "Introduction," *in* Mute Witnesses: Trace Evidence Analysis xi (Max M. Houck ed., 2001). For analytical purposes, we prefer the broader term. The interpretative and inferential issues are the same for all forms of marks, patterns, impressions, and substances transferred or deposited at a crime scene, on a victim, or on an individual who had was present at the location of the crime or had contact with people or objects that were there. They are all "traces."

[2] For brevity, we restrict attention to cases in which the perpetrator is the source of the trace sample. Almost all of the discussion applies to cases in which the victim or objects at the location of the crime might be the source of traces on the defendant, his possessions, or lodgings. *E.g.*, United States v. Cuff, 37 F. Supp. 2d 279 (S.D.N.Y. 1999) (scrapings from defendant's fingernails); State v. Bible, 858 P.2d 1152 (Ariz. 1993) (bloodstains on defendant's shirt); People v. Castro, 545 N.Y.S.2d 985 (Sup. Ct. 1989) (bloodstains on defendant's watch).

Although we use the terminology of criminal cases, trace evidence also can be used in civil cases in which the identity of a wrongdoer is disputed. *See, e.g.*, Seth Shulman, Tracking Sootprints, Technology Rev., Oct. 1997, at 11, 13 (describing studies of the of forging and describing this link is the subject of this chapter and the next one. This chapter concerns the fundamental reasoning of identification

Of course, some trace evidence requires no scientific analysis. The defendant's wallet located in a murdered woman's bedroom[3] or a camera taken from a rape victim that contains pictures of the victim's family and is found in the defendant's possession[4] obviously associates the defendant to the victim. But with traces whose identifying characteristics are not visible to the naked eye or other unaided senses, ascertaining any association requires the assistance of technology to detect the characteristics. In addition, determining the extent to which the more esoteric trace evidence narrows the set of possible suspects requires specialized statistical knowledge and study. Finally, explaining these matters in a way that meets the needs of lay factfinders and that is scientifically accurate poses the presentation or interpretation problem that is the subject of the next two chapters. In the remainder of this chapter, we describe the logical structure of the problem of inferring identify.

§13.3.1 Matches, Non-Matches, and Hypotheses

In general, the value to the investigator of trace evidence turns on three factors: (1) collection and handling, (2) analysis, and (3) discriminating power. For concreteness, consider a bloodstain on a broken window through which a burglar apparently entered a store. Collection and handling refers to the process by which the evidence is obtained, transported, and preserved. A criminalist might remove a portion of glass with the stain on it, place it in a suitable container, and tag it. "Analysis" refers to the study of the trace in the laboratory. An analyst might remove the dried blood and perform tests for various genetic markers. The genetic markers in the trace evidence sample might be compared to those in a sample from a defendant. If the collection and handling of the trace evidence is such that the stain from the store window is indeed the one compared to the sample from the defendant, and if the markers in both samples are different, then the defendant cannot be the source of the stain. But if the types are the same, then the match tends to prove that the defendant is the source of the trace sample.[5] If the analyst cannot discern

structure of soot that might permit identification of individual polluters, supporting class actions for damages from polluters whose emissions exceed legal limits or "to force tighter emission standards for airports or power plants").

[3] People v. Barney, 10 Cal. Rptr. 2d 731 (Cal. Ct. App. 1992).

[4] United States v. Jakobetz, 747 F. Supp. 250 (D. Vt.), *aff'd*, 955 F.2d 786 (2d Cir. 1990).

[5] This describes the match/no-match classification used in most forensic identification fields. When the differences are measured in a quantitative scale, however, the

whether the types are really the same or different because of limitations in the analytic technique or the quality of the samples, the analysis is simply inconclusive.[6]

Precisely how much a match tends to establish identity depends on the discriminating power of the genetic markers used in the analysis. If it were known that only one person in the world possesses the markers, then the inference that the defendant is the source of the stain would be irresistible. Such evidence is individualizing. But if it were known that everyone in the world possessed the markers, then the evidence would be worthless. It would not narrow the class of possible suspects, and it would not distinguish the defendant from anyone else in the population. In sum, the probative value of trace evidence to establish that a defendant is the source of the trace is a function of the integrity of the collection and handling of the evidence, the accuracy of the analysis, and the discriminating power of the characteristics uncovered by that analysis.

These three aspects of the evidence or its production correspond to three hypotheses that might explain how a match could be found between a sample reportedly taken from the crime scene and a sample said to be from the defendant — even though the defendant actually left no such trace. These three hypotheses as to innocence are summarized in the lower portion of Table 13-1. First, there is the possibility that the trace evidence sample does not originate from the crime scene or that the sample thought to be the defendant's comes from someone else. In other words, the evidence has been confused with material from other places or people.[7] This could happen, for instance, if the laboratory somehow switched vials of blood from two suspects, so that the vial marked as the defendant's contains the blood of the other suspect. The analytical procedure then could be accurate in that the trace evidence sample truly matches a suspect's

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classification is a decision imposed on a more subtle reality. *See, e.g.,* Franco Taroni et al., Data Analysis in Forensic Science: A Bayesian Decision Perspective (2010). An exclusion is really a finding that a likelihood ratio (*infra* Chapter 14) is close to zero.

[6] Again, criminalists have their own terminology in which the "analysis" phase is a special part of what they call the ACE (analysis, comparison, and evaluation) method. *See, e.g.,* Scientific Working Group on Friction Ridge Analysis, Study, and Technology, Friction Ridge Methodology for Latent Print Examiners, Aug. 22, 2002, *available at* http://www.swgfast.org/CurrentDocuments.html (last viewed June 16, 2010). As used here, "analysis" encompasses all these activities.

[7] The confusion could result from a mix-up in the laboratory or at a site at which the evidence was stored before reaching the laboratory. It could also be the consequence of police misconduct. *See* Kelly M. Pyre, Forensic Science Under Siege: The Challenges of Forensic Laboratories and the Medico-legal Death Investigation System (2007); Nelson E. Roth, The New York State Police Evidence Tampering Investigation: Report to the Honorable George Pataki, Governor of the State of New York (1997); Gary Taylor, Faked Evidence Becomes Real Problem — From Fingerprints to Photos to Computer Data, Lawyers are Learning to be Vigilant, Nat'l L.J., Oct. 9, 1995.

sample, but the inference that it is the defendant who matches would be wrong. This type of error can be called a handling error.

Second, there is the possibility that the characteristics of the samples are not those reported by the laboratory — the laboratory analysis is in error. This type of mistake can be deemed an analytic error.[8]

Third, even if the match is real and pertains to the named sources of the samples, it might be a coincidence. There is no collection or labeling error and no analytic error, but the defendant has the misfortune to possess the same identifying features that the true source of the trace evidence has. This third type of error can be called a spurious match error — a match exists, but it is spurious. Table 13-1 summarizes these possibilities.

Table 13-1. Hypotheses That Might Explain a Reported Match Between Samples Said to Be from the Defendant and From a Crime Scene

- Identity — S_D: Defendant is the source of the trace
- Non-identity — not-S_D: Defendant is not the source of the trace, and the reported match is due to:
  - Handling error
    (a sample is not from the designated source; the defendant does not match the trace),
  - Analytic error
    (a sample is not of the type reported; the defendant does not match the trace), or
  - Spurious match
    (the trace matches the defendant even though it did not come from the defendant)

[8] Such laboratory errors can be the result of technical limitations (the measurements are not perfectly accurate every time) or human failings (including malfeasance). For example, an FBI analyst pleaded guilty "to a one-count criminal information charging that she made false statements in . . . over 100 casework reports [in that she] falsely certified that she properly completed several control tests, knowing that she had in fact failed to perform them." U.S. Department of Justice, Press Release, Former FBI Biologist Pleads Guilty to Filing False DNA Laboratory Reports, May 18, 2004. (However, "FBI and Department of Justice analyses, including the retesting of the evidence in many of the cases, have demonstrated that [the] actions did not affect the outcome in any criminal case in which her test results were presented as evidence." Id.)

If the jury finds the three hypotheses of non-identity untenable it can conclude that the defendant is the source of the trace evidence, a proposition that we shall abbreviate S_D, S referring to "source" and D to the named defendant (or suspect). Although S_D states an association between the defendant and the crime scene, a mere association is not tantamount to guilt. It does not necessarily prove that the defendant personally was present,[9] and even if the defendant's presence is established, it does not mean that he acted with criminal intent. In a rape case, for instance, S_D could mean that the defendant's semen was present on the victim, but the defendant might maintain that the stain is the product of consensual sex. Nevertheless, scientific knowledge and more conventional evidence can help in assessing the relative plausibility of the competing hypotheses of identity, handling error, analytic error, and coincidence. In the example of a bloodstain on a broken window, the evidence at hand is that the laboratory has found (rightly or wrongly) that the trace sample has certain characteristics and that the defendant's sample has the same characteristics.[10] The judge or jury must decide whether this evidence is better explained by the hypothesis that the defendant is the source of the trace (S_D) than by the opposing claim (not-S_D) that someone other than the defendant is the source and the match is the result of handling error, analytic error, or coincidence.[11]

[9] Thus, it might be argued that even though the defendant is the source of the crime-scene sample, that sample was "planted" to incriminate the defendant. *See, e.g.*, Cooper v. Brown, 565 F.3d 581, 583, 595–609 (9th Cir. 2009) (opinion dissenting from the denial of a petition for rehearing en banc, discussing chemical "test results we already have [that] strongly suggest that [petitioner's] blood was planted on the t-shirt."); People v. Simpson, No. BA 097211, 1995 WL 697930, at *1 (Cal. Super. Ct. L.A. County, Sept. 28, 1995) (Tr., Closing Argument by Mr. Scheck). More definitive examples of planting are given in Boris Geller et al., A Chronological Review of Fingerprint Forgery, 44 J. Forensic Sci. 963 (1999).

[10] Technically, the evidence is an assertion of what the laboratory has found. In what follows, we assume that the laboratory has found what the witness says it has found. This does not mean that the finding is correct — only that it is correctly reported.

[11] Indeed, for every other individual X_i who might be the source, we can write the hypothesis S_i that X_i is the source; then not-S_D is the disjunction of all the hypotheses S_i. In other words, not-S_D asserts that either individual number 1, or 2, or . . . , or m, is the source (where the defendant is not in the numbered list and m is the number of suspects other than the defendant). Symbolically, not-$S_D = \cup S_i$, where $\cup S_i$ denotes the union (or disjunction) of all the events (or claims) S_i for which $X_i \neq D$.

§13.3.2 Exclusions

Courts and investigators commonly speak of trace evidence as excluding suspects.[12] An individual is said to be excluded as a possible source when his type clearly differs from that detected in the trace evidence. In a rape case involving a semen stain on a sheet from the victim's bed, for instance, the state might type the victim's boyfriend to exclude him as the source.[13]

A suspect who is excluded rarely would be prosecuted.[14] At least with immutable characteristics such as blood groups, a true exclusion disposes of the claim that the suspect is the source. Unless the government shows that the exclusion could be spurious or advances a tenable theory as to how a defendant who is not the source of the trace evidence could be guilty,[15] the exclusion should be dispositive under the doctrine that where uncontroverted physical facts contradict the testimony of a witness, that testimony cannot be accepted and a verdict based on it cannot be sustained.[16]

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[12] The absence of a trace is not necessarily an exclusion. When juries come to expect fingerprint or other trace evidence, the prosecution may be allowed to explain its absence to counter a possible "negative" inference. *See, e.g.*, Steven A. Saltzburg, A Special Aspect of Relevance: Countering Negative Inferences Associated with the Absence of Evidence, 60 Cal. L. Rev. 1011 (1978).

[13] *See, e.g.*, People v. Venegas, 954 P.2d 525 (Cal. 1998); State v. Hammond, 604 A.2d 793 (Conn. 1992).

[14] In the event of a prosecution, the government would be constitutionally obligated to disclose the fact of an exclusion to the defense. *See* Brady v. Maryland, 373 U.S. 83 (1963) (due process requires government to disclose exculpatory evidence in its possession); Padgett v. State, 668 So. 2d 78, 82–83 (Ala. Ct. Crim. App. 1995) (applying *Brady* to exculpatory blood serum-protein evidence).

[15] In a case in which several men rape a woman, for instance, the failure to find one man's semen might not be exculpatory. *E.g.*, Harlan Levy, And the Blood Cried Out 79–81 (1996).

[16] *See* Anonymous v. Anonymous, 460 P.2d 32, 35 (Ariz. Ct. App. 1969) ("To hold [that results that excluded the husband as the father of his wife's child were not conclusive] would be tantamount to this court, by judicial decree, declaring the laws of motion and gravity to be repealed"); Budaj v. Connecticut Co., 143 A. 527 (Conn. 1928) ("[w]here testimony is thus in conflict with indisputable physical facts, the facts demonstrate that the testimony is either intentionally or unintentionally untrue, and leave no real question of conflict of evidence for the jury concerning which reasonable minds could reasonably differ"); Roma v. Thames River Specialties Co., 96 A. 169 (Conn. 1915) (the trial judge "would have failed in his duty" if he had not set aside the verdict when "the laws of mechanics, as testified to and uncontradicted, tended to prove [the claimant's] story impossible").

Furthermore, "a trial court also has the authority in a criminal case to refuse to enter judgment on a verdict of guilt, and to remit the prosecution to a new trial, if it is persuaded that the verdict is contrary to the great weight of the evidence." Stephen J. Ceci & Richard D. Friedman, The Suggestibility of Children: Scientific Research and Legal Implications, 86 Cornell L. Rev. 33, 107 n.311 (2000).

For example, in *State v. Hammond*,[17] the defendant was convicted of kidnapping and rape. Testimony of the victim and the defendant's friends resulted in "a strong case for the culpability of the defendant."[18] However, on the basis of tests done by the Connecticut state police crime laboratory and the FBI, it was "physically impossible for the defendant to have been the man who sexually assaulted the victim unless both the blood typing tests and the DNA tests made on the samples taken from the victim's clothing [were] for some reason unreliable."[19] Regarding the state's theories of denaturing and contamination of the stains "untenable" on "the present record,"[20] the Connecticut Supreme Court invoked the doctrine of physical impossibility and remanded the case to the trial court to decide whether a new trial was justified.[21]

§13.3.3 Probabilities of Error

Section 13.3.1 identified three possible rival hypotheses to the claim S_D that the trace evidence sample came from the defendant: handling error on the scene, in the laboratory, or elsewhere; analytic error in the laboratory testing; and spurious association. Some scientists have urged that probabilities for these events be computed and presented to juries. But can a probability that the two traces would be found to match when in fact their features are different be calculated? Methods of collecting evidence and the steps taken by police to ensure the integrity of the evidence can be subjects for pre-trial discovery or cross-examination, but it is hard to imagine how the probability of false-positive error[22] at this stage could be quantified.[23]

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[17] 604 A.2d 793 (Conn. 1992).

[18] Id. at 798.

[19] Id. at 800.

[20] Id. at 803.

[21] The court reasoned that "[t]he logical inconsistencies that we have found in the prosecution's theory of the case were not brought to the court's attention by counsel for the defense. It is possible that, fully informed, the trial court might have ruled differently on the motion for a new trial. . . . [W]e therefore remand this case to the trial court for reconsideration of the defendant's motion to set aside the verdict, . . ." Id. at 804.

[22] A "false positive" is a report of a match between the trace evidence sample and the sample from the suspect when the samples do not really match. It can arise because of either (1) collection or handling error or (2) analytic error in the laboratory. A coincidental match is not a false positive in this sense; rather, it represents a spurious association between samples that do match.

[23] In theory, phony crimes might be reported with trace evidence left at the putative crime scenes. The performance of the police in collecting and handling this evidence later could be evaluated. However, producing convincing mock crime scenes, victims, and witnesses would be difficult; the process would be expensive; scarce resources would

As for the probability of false-positive laboratory error, some commentary proposes using the proportion of false-positive errors that the particular laboratory has experienced in blind proficiency tests or the rate of false positives on proficiency tests averaged across all laboratories.[24] In an external proficiency test, a laboratory receives a sample from an outside agency and analyzes it. In a blind test, the laboratory does not know that it is being tested. In theory, at least, such tests are designed to permit a laboratory to verify that its procedures are satisfactory or to make improvements in those procedures.

How useful proficiency test scores are in estimating laboratory error rates is debatable. The following arguments against relying on them have been put forward: An industry-wide rate is an average that penalizes better-performing laboratories and advantages the worse-performing ones.[25] The tests might not be representative of practice.[26] If the testing leads to improvements, the past error rate may be outdated.[27] In addition, because it is difficult and expensive to conduct blind tests for many types of trace evidence, laboratories will undergo relatively few tests per year. Yet it takes many observations to determine how rarely low-probability events occur. If the false-positive probability were, say, 0.001, it would take tens of thousands of proficiency tests to estimate that probability accurately.[28]

Most commentators who urge the use of proficiency tests to estimate the probability that a laboratory has erred in a particular case agree that blind proficiency testing cannot be done in sufficient numbers to yield an

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be diverted from actual cases; and the numbers of such "police proficiency tests" would be small and localized. Thus, the prospect of generating any useful statistics on the probability of handling errors that might falsely incriminate anyone on the part of specific officers, precincts, or departments seems remote.

[24] *E.g.*, National Research Council Committee on DNA Technology in Forensic Science, DNA Technology in Forensic Science 94 (1992) ("proficiency tests provide a measure of the false-positive and false-negative rates of a laboratory"); Jonathan J. Koehler, Error and Exaggeration in the Presentation of DNA Evidence at Trial, 43 Jurimetrics J. 21, 37–38 (1993); Barry Scheck, DNA and *Daubert*, 15 Cardozo L.J. 1959, 1984 n.93 (1994); *infra* §14.1.1.

[25] Bruce Budowle et al., A Perspective on Errors, Bias, and Interpretation in the Forensic Sciences and Direction for Continuing Advancement, 54 J. Forensic Sci. 798, 803 (2009).

[26] Id.

[27] National Research Council Committee on DNA Technology in Forensic Science, *supra* note 24, at 89 ("errors on proficiency tests do not necessarily reflect permanent probabilities of false-positive or false-negative results"); Budowle et al., *supra* note 24, at 802 ("Because . . . corrective action [must be] taken, . . . the calculation of the individual's current error rate should not include that past error.").

[28] *See, e.g.*, National Research Council Committee on DNA Forensic Science: An Update, The Evaluation of Forensic DNA Evidence 85–87 (1996) [cited as NRC DNA II].

accurate estimate of a small error rate. However, they maintain that proficiency tests, blind or otherwise, should be used to provide a conservative estimate of the false-positive error probability.[29] For example, if there were no errors in 100 tests, a 95 percent confidence interval would include the possibility that the error rate could be almost as high as 3 percent.[30] They reject the criticism that industry-wide rates do not apply to individual laboratories on the ground that a group mean or base rate is more accurate than no information at all and that when more specific information on a laboratory, case, or examiner is available, it should be used to adjust the industry baserate up or down.[31]

Whether or not a case-specific probability of laboratory error can be estimated with proficiency tests, traditional legal and scientific procedures can help to eliminate the hypotheses of handling or analytic error. Scrutinizing the chain of custody, examining the laboratory's protocol, verifying that it adhered to that protocol, and conducting confirmatory tests if there are any suspicious circumstances can be effective.[32]

§13.3.4 Coincidence

The remaining rival hypothesis to S_D is spurious association — the defendant is not the source of the trace; the police and the laboratory made no handling or analytic errors, and the defendant just happens to have the same type as the true source. The straightforward way to eliminate this hypothesis would be to test all conceivable sources of the trace evidence. If everyone except the defendant does not match the trace evidence, then the conclusion that the defendant is the source is inescapable. However, exhaustive, error-free testing of the population of conceivable suspects

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[29] *E.g.*, Jonathan J. Koehler, DNA Matches and Statistics: Important Questions, Surprising Answers, 76 Judicature 222, 228 (1993); Richard Lempert, After the DNA Wars: Skirmishing with NRC II, 37 Jurimetrics J. 439, 447–448, 453 (1997).

[30] *See* NRC DNA II, *supra* note 28, at 86 n.1. For an explanation of confidence intervals, see *supra* §§12.6.4, 12.8.4(d).

[31] *E.g.,* Jonathan J. Koehler, Fingerprint Error Rates and Proficiency Tests: What They Are and Why They Matter, 59 Hastings L.J. 1077, 1088–1089 (2008).

[32] *E.g.*, Jonathan J. Koehler, On Conveying the Probative Value of DNA Evidence: Frequencies, Likelihood Ratios, and Error Rates, 67 U. Colo. L. Rev. 859, 866 (1996) ("In the *Simpson* case, [l]aboratory error was unlikely because many blood samples were tested at different laboratories using two different DNA typing methods."); William C. Thompson, DNA Evidence in the O.J. Simpson Trial, 67 U. Colo. L. Rev. 827, 827 (1996) ("the extensive use of duplicate testing in the *Simpson* case greatly reduced concerns (that are crucial in most other cases) about the potential for false positives due to poor scientific practices of DNA laboratories").

rarely is feasible.[33] The suspect population[34] normally defies any enumeration,[35] and in many crimes when trace evidence is found, the population of possible perpetrators is so huge that even if all its members could be listed, they could not all be tested.[36]

Because direct elimination of all alternative sample sources is typically impossible,[37] the plausibility of spurious association often is

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[33] In some situations, exhaustive testing may be possible. *See, e.g.*, Mindy Sink, An Accusation of Rape Hangs over Colorado, N.Y. Times, Dec. 29, 2001 (reporting that Boulder police asked University of Colorado football players to provide DNA samples in response to a female student's accusation that she was raped repeatedly at a party attended by some players and high school recruits); Jack Leonard, Using DNA to Trawl for Killers, L.A. Times, Mar. 10, 2001, at A1 (examining "blood from 32 men at a nursing home where a patient in a coma had been raped and impregnated," detectives in Lawrence, Mass., "discovered that a nurse's aide . . . was the father"). The first massive effort to test DNA in an entire suspect population occurred in response to the killings of two teenage girls near the small English village of Narborough. Police requested that every man between the ages of 13 and 30 in three nearby villages, more than 5,000 people, submit blood samples for DNA analysis. *See* Jerry Adler & John McCormick, The DNA Detectives, Newsweek, Nov. 16, 1998, at 66, 66. However, Colin Pitchfork, the man whose DNA ultimately was linked to the killings, was not detected in the massive testing. Rather, he was arrested after police learned that he had arranged for a coworker to take the test in his place. *See* Joseph Wambaugh, The Blooding (1989).

[34] A phrase like "potential source population" would be more precise than "suspect population," since we are speaking of the set of all people who might have contributed the trace evidence sample. *See* Koehler, *supra* note 29, at 227; Jonathan J. Koehler, Error and Exaggeration in the Presentation of DNA Evidence, 34 Jurimetrics J. 21, 26 (1993). However, this population will usually be similar to the group of people who could have committed the crime, Richard Lempert, The Suspect Population and DNA Identification, 34 Jurimetrics J. 1, 3–4 n.8 (1993). Unless there is some reason to distinguish between the two, this chapter uses the shorter phrase "suspect population."

[35] *See, e.g.*, Peter Donnelly & Richard D. Friedman, DNA Database Searches and the Legal Consumption of Scientific Evidence, 97 Mich. L. Rev. 931, 947 n.54 (1999).

[36] In the United Kingdom and Europe, mass DNA screenings in small towns have been undertaken. *See, e.g.*, D.H. Kaye, Science in Evidence 222–226 (1997). Sometimes they have proved successful in flushing out the culprit. *See, e.g.,* Wambaugh, *supra* note 33 (telling the story of the first mass screening, in which DNA testing exculpated one suspect who had confessed to the rape-murder of a child and initially failed to detect the actual murderer, who had convinced a coworker to impersonate him in submitting a blood sample). In the United States, the practice, applied on a smaller scale, has produced mixed results. *See, e.g.*, Philip P. Pan, Pr. George's Chief Has Used Serial Testing Before; Farrell Oversaw DNA Sampling of 2,300 in Fla., Wash. Post, Jan. 31, 1998, at B1.

[37] When specific individuals are plausible sources of the trace evidence, direct elimination is obviously advisable — and commonly undertaken. *See, e.g.*, People v. Venegas, 954 P.2d 525 (Cal. 1998) (boyfriend in sexual assault cases tested, not because he was suspected of an assault, but to eliminate the possibility that the semen sample that matched the defendant might be the boyfriend's). This is not equivalent to exhaustive testing, but eliminating specific individuals provides additional support for the hypothesis that the defendant is the source.

addressed indirectly by efforts to determine how rare the incriminating features are. If these features are common, then the match is not very significant, but if they are highly unusual, then the match is less likely to be spurious. Thus, experts sometimes testify to relative frequencies or probabilities of finding matching samples in the general population. However, quantitative testimony sometimes poses problems of comprehension for judges and juries, and various types of quantitative and qualitative presentations have been proposed to convey the probative force of the fact that the defendant matches the trace evidence. The next two chapters therefore consider what has been called "the presentation problem."[38] They discuss the admissibility and the relative merits of various quantitative and qualitative formats for presenting the laboratory's findings about trace evidence that tends to associate a defendant with a crime.

[38] Mike Redmayne, Expert Evidence and Criminal Justice 58 (2001).