

2007

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Recommended Citation

David H. Kaye, *The Science of DNA Identification: From the Laboratory to the Courtroom (and Beyond)*, 8 MINN. J.L. SCI. & TECH. 409 (2007).

Available at: <https://scholarship.law.umn.edu/mjlst/vol8/iss2/4>

The Science of DNA Identification: From the Laboratory to the Courtroom (and Beyond)

David H. Kaye*

For much of the Twentieth Century, the scientific icon was the atom. This was the “atomic age”—a period of atomic bombs, atomic submarines, atomic clocks, and nuclear medicine. As the Twenty-first Century unrolls, the dominant scientific icon is no longer the atom; it is the double helix, the backbone of the DNA molecule.¹ The sequences of the “nucleotide base pairs” that link the two strands of the double helix are seen by some bioethicists as the “secret future diaries” of human beings² and by some scientists as “in essence, . . . what makes humans human.”³

This imagery and essentialism is exaggerated,⁴ but that is a topic for another occasion. This article will focus on

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This article was derived from a Deinard Memorial Lecture on Law and Medicine, at the University of Minnesota Law School, on January 31, 2006.

1. See DOROTHY NELKIN & M. SUSAN LINDEE, *THE DNA MYSTIQUE: THE GENE AS A CULTURAL ICON* (1995); Dorothy Nelkin, *Molecular Metaphors: The Gene in Popular Discourse*, 2 NATURE REV. GENETICS 555 (2001).

2. George J. Annas, *Privacy Rules for DNA Databanks: Protecting Coded 'Future Diaries,'* 270 JAMA 2346 (1993).

3. Julie Meyne, *The Human Genome Project: Impact on the Prevalence of Diabetes*, Aug. 1997, <http://darwin.nmsu.edu/~molbio/diabetes/human.html>. Cf. Nicholas Wade, *Life Is Pared to Basics*, N.Y. TIMES, Dec. 14, 1999, at F3 (reporting the concern expressed by a medical ethicist that “when biologists sequenced the first human chromosome last month, they called it ‘the first chapter in the book of life, as if life is chromosomes’”).

4. See, e.g., RICHARD LEWONTIN, *THE TRIPLE HELIX: GENE, ORGANISM, AND ENVIRONMENT* (2000); Eric T. Juengst, *FACE Facts: Why Human Genetics Will Always Provoke Bioethics*, 32 J.L. MED. & ETHICS 267 (2004).

sequences of DNA base-pairs that are of little or no importance in medicine but that have become exceedingly important in law. I refer to the genetic features used by forensic scientists to characterize biological trace evidence that contains DNA—primarily blood stains, semen, saliva, and hair. The variations in DNA sequences, which are found at particular locations, or “loci,” in the genome, are known as “alleles.” Matching DNA alleles can be used to ascertain the likely source of a crime-scene sample and to establish family relationships. Testimony as to these DNA loci has appeared in cases of child support, domestic relations, immigration and naturalization, slander, and even judicial discipline. But it is the criminal justice system that has benefited the most from forensic DNA identification, both in terms of exonerating the innocent and convicting the guilty.

This article will survey the history, nature, and uses of the science of human DNA identification as it has moved from the laboratory to the courtroom. Part I describes the process by which courts admit (or exclude) scientific evidence and how scientists have responded to the legal milieu. The tale is one of legal doctrine, of lawyers and their limitations, of courts and confusion, of journalists and misreporting, and of adversarial science and egos.⁵ Part II moves from these doctrinal and historical developments in the law of evidence to several of the ethical, social, and constitutional questions created by current developments in forensic DNA analysis, and by the creation and expansion of forensic DNA repositories and databases.

I. THE LEGAL ACCEPTANCE OF DNA IDENTIFICATION EVIDENCE

Only a few concepts from the law of evidence are needed to describe the judicial response to efforts to introduce DNA

5. The historical survey pretermits the use of DNA typing in post-conviction relief. These cases have played an extremely important role in criminal justice, but they are less directly connected to admissibility issues. For discussions of DNA exonerations, see EDWARD CONNORS ET AL., CONVICTED BY JURIES, EXONERATED BY SCIENCE: CASE STUDIES IN THE USE OF DNA EVIDENCE TO ESTABLISH INNOCENCE AFTER TRIAL (1996); BARRY SCHECK ET AL., ACTUAL INNOCENCE: FIVE DAYS TO EXECUTION, AND OTHER DISPATCHES FROM THE WRONGLY CONVICTED (2000); Paul C. Giannelli, *Impact of Post-Conviction DNA Testing on Forensic Science*, 35 NEW ENG. L. REV. 627 (2001); Seth F. Kreimer & David Rudovsky, *Double Helix, Double Bind: Factual Innocence and Postconviction DNA Testing*, 151 U. PA. L. REV. 547 (2002).

evidence. All expert witnesses—scientific and otherwise—are expected to have specialized knowledge that can assist the jury in understanding the facts. In almost all jurisdictions, however, scientific experts must clear an additional hurdle. This special scrutiny of scientific methodology varies among jurisdictions, but two major standards have emerged, the general-acceptance standard and the *Daubert* standard. The general-acceptance standard, introduced in a 1923 case entitled *Frye v. United States*, requires proof that most knowledgeable scientists accept a theory or technique as valid and reliable.⁶ The *Daubert* standard, adopted in 1993 in *Daubert v. Merrell Dow Pharmaceuticals*, does not treat general acceptance among scientists as definitive but considers it to be one factor that helps demonstrate the underlying validity of the theory.⁷ The two standards are quite flexible and depend entirely on the rigor with which the court chooses to apply them.⁸

Starting in the late 1980s, courts across the country began to apply these standards to DNA evidence.⁹ The ensuing legal history can be divided into at least four phases: (1) a period of uncritical acceptance of Variable Number Tandem Repeat (VNTR) typing; (2) serious challenges to analytical methods and the statistical interpretation of the results; (3) renewed acceptance of DNA evidence; and (4) acceptance of more advanced systems of DNA analysis.

A. PHASE I: UNCRITICAL ACCEPTANCE OF VNTRS

The first genetic loci used in forensic testing were Restriction Fragment Length Polymorphisms (RFLPs). These are variations in the length of the DNA sequence between two sites at which bacterial enzymes cut the long DNA molecule into pieces. For example, the population might include some people with 3,200 base pairs between the two restriction sites, some with 1,200 base pairs, and some with both (one on each chromosome). Human geneticists had been using RFLP technology for years as markers for mutations that produced

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

7. 509 U.S. 579 (1993).

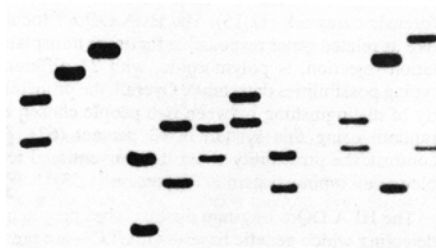
8. See D.H. KAYE ET AL., *THE NEW WIGMORE, A TREATISE ON EVIDENCE: EXPERT EVIDENCE* (2004).

9. By the end of the 1980s, a substantial minority of federal circuits and states had rejected the general-acceptance standard of *Frye* in favor of a “reliability-plus” standard comparable to *Daubert*. See *id.*

genetic diseases. These markers, however, were usually simple systems with a few easily distinguishable alleles, such as the two postulated above.

The type of loci that proved powerful enough for human identification was discovered serendipitously in 1984 by geneticist, Sir Alec Jeffries, at the University of Leicester.¹⁰ These VNTR loci involve many possible alleles that are almost continuous in their lengths. A short sequence of base pairs is repeated, back to back, various numbers of times. Instead of only two possible alleles (such as the 1,200 and 3,200 base-pair alleles), there can be many alleles of different lengths. The lengths have no medical significance, but they do give rise to measurable differences that enable analysts to distinguish among different individuals. Figure 1 is an "autoradiograph" showing the alleles of one VNTR locus in eleven different people. The DNA fragments, which carry a negative charge, have been pulled through a slab of gelatinous material by an electric field so that they have moved distances proportional to their lengths. The dark spots mark the final positions of the fragments. Shorter fragments have moved farther down the gel. Each person has either one or two alleles (discernibly different fragment lengths) that appear in each vertical lane.

FIGURE 1. AUTORADIOGRAPH OF VNTR ALLELES AT A SINGLE LOCUS IN ELEVEN INDIVIDUALS¹¹



10. See Alec J. Jeffreys, *Highly Variable Minisatellites and DNA Fingerprints*, 15 *BIOCHEMICAL SOC'Y TRANS.* 309 (1987); Alec J. Jeffreys et al., *DNA "Fingerprints" and Segregation Analysis of Multiple Markers in Human Pedigrees*, 39 *AM. J. HUM. GENETICS* 11 (1986); A.J. Jeffreys et al., *Individual-Specific 'Fingerprints' of Human DNA*, 316 *NATURE* 76 (1985); Alec J. Jeffreys et al., *Hypervariable "Minisatellite" Regions in Human DNA*, 314 *NATURE* 67 (1985).

11. The autoradiograph was produced by the FBI in 1988. It is reproduced from OFFICE OF TECHNOLOGY ASSESSMENT, *GENETIC WITNESS: FORENSIC USES OF DNA TESTS* 47 (1990).

In the earliest DNA cases, the technology was the subject of lopsided testimony. In some instances, defendants objected that the technology as adapted to forensic usage was not generally accepted or adequately validated, but they produced no experts to question the claim of general acceptance. In one Texas case, *Kelly v. State*,¹² the defense produced an expert who, as the court delicately put it, “was certified to teach life and earth sciences in public schools” and who testified that radioactivity, which had been introduced into medicine in the late 1930s,¹³ was too new to be generally accepted.¹⁴ Not surprisingly, this idiosyncratic view did not prevail over the unequivocal assurances of general acceptance from three university or medical school professors who testified for the prosecution.

The courts in these lopsided cases had little difficulty finding general acceptance or scientific validity.¹⁵ Such cases can have a snowball or avalanche effect. Other courts cite them as having found general acceptance or scientific validity. The snowball grows until it becomes an avalanche, increasingly difficult to stop even if there are serious grounds to question the scientific technique. This is currently the situation with dermatoglyphic fingerprinting. Fingerprints obviously are highly variable, but the validity and reliability of analysts working with latent prints of varying quality have not been rigorously studied. Yet, because the technique is so well ensconced, courts have been reluctant to apply faithfully the *Daubert* standard of scientific validity.¹⁶

B. PHASE II: CHALLENGES TO ANALYTICAL METHODS, STATISTICS, AND POPULATION GENETICS MODELS

Despite the initial momentum of DNA evidence, defense counsel were able to raise important questions. The details of the laboratory procedures were questioned, and limitations were identified in the statistical and population-genetics models used in estimating the frequencies of the DNA types.

12. 792 S.W.2d 579, 583 (Tex. Ct. App. 1990).

13. See, e.g., João José Pedroso de Lima, *Radioisotopes in Medicine*, 19 EUROPEAN J. PHYSICS 485, 485 (1998).

14. Radioactive isotopes are used in producing the bands in the autoradiograph.

15. See 1 MCCORMICK ON EVIDENCE § 205(B) (Kenneth S. Broun ed., 6th ed. 2006).

16. See, e.g., *id.* § 207(A).

One case that undermined judicial confidence is *People v. Castro*.¹⁷ In this case, the defense found strong grounds to question the interpretation of the DNA tests conducted by Lifecodes, a commercial laboratory specializing in forensic DNA testing. The defense witnesses included Eric Lander, a mathematician-turned-biologist at MIT who was to become a leader in the Human Genome Project. Richard Roberts, who was to receive the Noble prize a few years later, testified for the state at a twelve-week hearing that resulted in a transcript of some 5,000 written pages. Judge Gerald Sheindlin, who went on to write two books on DNA evidence,¹⁸ excluded the testimony of a DNA match, referring to the defense's "piercing attack on each molecule of evidence."¹⁹

When scientists of this caliber differ, courts normally are at a loss to decide who is right. Here, the court had no difficulty. After reviewing Lander's concerns, Roberts proposed that the scientists for both parties meet without the lawyers. This unchaperoned *tête-à-tête* resulted in a joint statement concluding that "the DNA data in this case are not scientifically reliable enough to support the assertion that the samples do or do not match."²⁰ The scientists subscribing to the statement agreed that Lifecodes had failed to perform experiments that might have explained certain anomalous bands and that the reported probability of a random match "understates the actual probability."²¹

Despite the defects in the laboratory work in *Castro* and a few other cases, most courts continued to find forensic RFLP-

17. 545 N.Y.S.2d 985 (Sup. 1989). Indeed, *Castro* was said to be "the first serious challenge to DNA 'fingerprinting.'" Robert D. Mcfadden, *Reliability of DNA Testing Challenged by Judge's Ruling*, N.Y. TIMES, Aug. 15, 1989, at B1. According to Clay Strange,

what had been widely accepted in the press and hailed as a major advance was now viewed skeptically, even as unreliable by one *New York Times* reporter. The fact that *Castro* was based "on technical aspects of a particular case and not the fundamental scientific validity of DNA technology" was obscured.

Clay Strange, Book Review, *DNA's Search for Truth*, 83 JUDICATURE 165, 166 (1999).

18. BLOOD TRAIL: TRUE CRIME MYSTERIES SOLVED BY DNA DETECTIVES (1996); GENETIC FINGERPRINTING: THE LAW AND SCIENCE OF DNA EVIDENCE (1996).

19. *Castro*, 545 N.Y.S.2d at 996.

20. Roger Parloff, *How Barry Scheck and Peter Neufeld Tripped Up the DNA Experts*, AM. LAWYER., Dec. 1989, at 1.

21. *Id.*

VNTR analyses to be generally accepted, and a number of states provided for admissibility of DNA tests by legislation.²²

A more sweeping attack on DNA profiling that began in *Castro* led to a wave of cases in which many courts held that estimates of the probability of a coincidentally matching VNTR profile were inadmissible. These estimates relied on a simplified population-genetics model for the frequencies of VNTR profiles that treats each race as a large, randomly mating population. Some prominent scientists claimed that the applicability of the model had not been adequately verified and that it was inaccurate because ethnic or religious subgroups tend to mate preferentially among themselves.²³ A heated debate on the significance of this population substructure spilled over from courthouses to scientific journals and convinced the supreme courts of several states that general acceptance was lacking.²⁴ A 1992 report of the National Academy of Sciences (NAS), as a compromise, proposed a more “conservative” computational method, dubbed “the ceiling principle” by its inventor and National Research Council committee member, Eric Lander.²⁵ The apparent need for a compromise seemed to undermine the claim of scientific acceptance of the less conservative procedure that was in general use. Other NAS recommendations (for improvements in quality control and assurance and more objective standards for declaring matches) also were seen by some observers as demanding the exclusion of DNA evidence. An article by *New York Times* biomedical reporter Gina Kolata propounded a

22. *E.g.*, MINN. STAT. ANN. § 634.25. This statute provides that
In a civil or criminal trial or hearing, the results of DNA analysis . . .
are admissible in evidence without antecedent expert testimony that
DNA analysis provides a trustworthy and reliable method of
identifying characteristics in an individual’s genetic material upon a
showing that the offered testimony meets the standards for
admissibility set forth in the Rules of Evidence.

Presumably, it is intended to relieve the state of the burden of showing that a particular DNA typing method satisfies *Frye* (the standard used in Minnesota), but, by and large, the Minnesota courts have studiously ignored it. *See, e.g.*, *State v. Kromah*, 657 N.W.2d 564 (Minn. 2003).

23. *See, e.g.*, Leslie Roberts, *Fight Erupts over DNA Fingerprinting: A Bitter Debate Is Raging over How the Results of this New Forensic Technique Are Interpreted in Court*, 254 *SCIENCE* 1721 (1991)

24. *See* David H. Kaye, *DNA Evidence: Probability, Population Genetics, and the Courts*, 7 *HARV. J. L. & TECH.* 101 (1993).

25. COMM. ON DNA TECH. IN FORENSIC SCI., NAT’L RESEARCH COUNCIL COMM. ON DNA TECH. IN FORENSIC SCIENCE, *DNA TECHNOLOGY IN FORENSIC SCIENCE* (1992).

particularly tendentious view of the report.²⁶ After a special press conference called by Victor McCusick, the chairman of the committee, the *New York Times* (grudgingly if you read the fine print) confessed error.²⁷

C. PHASE III: RENEWED ACCEPTANCE

At this juncture the legal history entered a third phase. The 1992 NAS report's advocacy of the "ceiling principle" for computing random-match probabilities without assuming random mating within broadly defined races came in for withering criticism. Many population geneticists regarded this procedure as ad hoc and excessively conservative.²⁸ Before long, the procedure was denigrated as being neither a "ceiling" nor a "principle."²⁹ In 1996, a second NAS panel concluded that data collected on subpopulations from across the world confirmed that the usual method of estimating frequencies of VNTR profiles in broad racial groups generally was sound.³⁰ Moreover, in the period between the two reports, an FBI geneticist and Eric Lander joined forces to write commentary in *Nature* with the reassuring title "DNA Fingerprinting Dispute Laid to Rest."³¹ The article pointed to improvements in laboratory standards and additional research into subpopulations. Impressed with Lander's sudden, public conversion to the view that the population-genetics issues were no longer serious obstacles to admissibility, and reassured by the 1996 NAS report, courts began to regard concerns over population substructure as *passé*. In this manner, the courts almost invariably returned to the earlier view that the statistics associated with VNTR profiling are generally accepted and scientifically valid both in major population

26. Gina Kolata, *U.S. Panel Seeking Restrictions On Use of DNA in Courts*, N.Y. TIMES, Apr. 14, 1992, at A1. The article began by claiming that the committee had said that DNA typing "should not be allowed in court in the future unless a more scientific basis is established." It insisted that "[t]he new report . . . says courts should cease to admit DNA evidence . . ." *Id.*

27. Gina Kolata, *Chief Says Panel Backs Courts' Use of a Genetic Test*, N.Y. TIMES, Apr. 15, 1992, at A23.

28. See Peter Aldhous, *Geneticists Attack NRC Report as Scientifically Flawed*, 259 SCIENCE 755 (1993).

29. Kaye, *supra* note 24.

30. COMM. ON DNA TECH. IN FORENSIC SCIENCE: AN UPDATE, NAT'L RESEARCH COUNCIL, THE EVALUATION OF FORENSIC DNA EVIDENCE (1996).

31. Eric S. Lander & Bruce Budowle, *DNA Fingerprinting Dispute Laid to Rest*, 371 NATURE 735 (1994).

groups and in subgroups.³²

D. PHASE IV: ACCEPTANCE OF PCR-BASED METHODS

In the final phase of the judicial acceptance of DNA evidence, prosecutors moved away from VNTR loci and introduced matches based on other DNA features. Analysis of these sites of DNA variation was made possible by the use of the polymerase chain reaction (PCR). Discovered by the colorful Kary Mullis,³³ PCR is a chemical process that makes copies of small DNA fragments, then copies of copies, then copies of all those copies, and so on.³⁴ Contrary to the nomenclature of many judicial opinions, PCR is not a forensic typing method. It is simply a preliminary step. Once the particular loci of interest have been “amplified,” perhaps a million-fold, with PCR, they can be analyzed in various ways. The most common procedure examines Short Tandem Repeat (STR) loci, which have a core element of a handful of base pairs repeated a relatively small number of times. Per locus, they are less variable than VNTRs, but much easier to measure and interpret.³⁵

As results obtained with the PCR-based methods entered the courtroom, it became necessary to ask whether these methods also rested on a solid scientific foundation or were

32. Two cases illustrate these developments. In *People v. Miller*, 670 N.E.2d 721 (Ill. 1996), the Supreme Court of Illinois observed that “while there has been some controversy over the use of the product rule in calculating the frequency of a DNA match, that controversy appears to be dissipating.” *Id.* at 731-32. The court cited the Lander-Budowle paper as proof that “[t]he concerns . . . appear not to have been borne out by empirical studies.” *Id.* at 732. The next year, in *People v. Hickey*, 687 N.E.2d 910 (Ill. 1997), the same court determined that a *Frye* hearing no longer was required in light of *Miller* and the fact that

[t]he 1996 report concludes that “[t]he state of the profiling technology and the methods for estimating frequencies and related statistics have progressed to the point where the admissibility of properly collected and analyzed DNA data should not be in doubt” and that the report “also specifically concludes that sufficient data have been gathered to establish that the interim ceiling principle is not needed and further recommends that, in general, the calculation of a profile frequency should be made with the product rule.”

Id. at 291.

33. See KARY MULLIS, *DANCING NAKED IN THE MIND FIELD* (1998); Emily Yoffe, *Is Kary Mullis God?*, *ESQUIRE*, July 1, 1994, at 68.

34. See, e.g., *PCR TECHNOLOGY: PRINCIPLES AND APPLICATIONS FOR DNA AMPLIFICATION* (H.A. Erlich ed., 1989).

35. See JOHN M. BUTLER, *FORENSIC DNA TYPING: BIOLOGY, TECHNOLOGY, AND GENETICS OF STR MARKERS* (2d ed. 2005).

generally accepted in the scientific community. The opinions were practically unanimous in holding that the current laboratory procedures for STR typing (as well as earlier systems) satisfy these standards.³⁶ They also held that the so-called “product rule” for estimating the frequencies of DNA types in major population groups is scientifically sound and generally accepted for the loci investigated in these tests.³⁷

In sum, in little more than a decade, DNA typing made the transition from a novel set of methods for identification to a relatively mature and well studied forensic technology. Although some of the defense objections in this period seem misconceived or overblown, the adversary system is structured to exaggerate or amplify differences in the scientific community. Moreover, whatever hyperbole there was—and there was hyperbole on both sides—the defense criticisms contributed to improvements in protocols, more extensive proficiency testing, and research in population genetics and statistics.

II. EMERGING ETHICAL, SOCIAL, AND CONSTITUTIONAL CONCERNS

Although the most significant issues related to the admissibility of forensic DNA testing have been resolved, several aspects of the investigative phase of DNA work remain highly contentious. These include inferring race or ethnicity from crime-scene samples, acquiring DNA samples without consent or judicial warrants, and amassing and using DNA databases for law-enforcement purposes.

A. INFERRING RACE OR ETHNICITY FROM CRIME-SCENE SAMPLES

A former official at the National Human Genome Research Institute stated: “Of high concern to us is the use of DNA as a high-tech form of racial profiling, [to determine the] probabilities . . . of an individual being from this race or that ethnic group.”³⁸ But why should this practice be considered

36. 4 MODERN SCIENTIFIC EVIDENCE: THE LAW AND SCIENCE OF EXPERT TESTIMONY § 32:3 (David L. Faigman et al. eds., 2006).

37. See cases cited in *id.*

38. Kathy Hudson, Keynote Address at the American University Law Review Symposium: The Human Genome Project, DNA Science and the Law: The American Legal System’s Response to Breakthroughs in Genetic Science

“racial profiling”? In some cases, the crime-scene sample will point to African-Americans; in others, it will point to Whites. There is no pre-established racial profile. For Equal Protection purposes, it is comparable to relying on an eyewitness’s description of the culprit as Asian, or Hispanic, or Black, or White to focus an investigation.³⁹ Admittedly, the categories are socially constructed and imperfectly correlated with genetic markers, but anthropologists have produced ancestry-informative markers (AIMs),⁴⁰ and they may be roughly indicative of physical features.⁴¹ If genetic analysis of ancestry is reasonably accurate, one could argue that it is protective of the rights of minorities, as it reduces the risk of initial stereotyping and focuses the investigation on the group where it belongs.

B. ACQUISITION OF SUSPECTS’ DNA

Many more civil-liberties issues arise when police seek to acquire DNA samples from suspects for comparison to samples from crime scenes.⁴² The government must conform to the Fourth Amendment, which refers to “[t]he right of the people to be secure . . . against unreasonable searches and seizures” and specifies that “no Warrants shall issue, but upon probable cause”⁴³ However, precisely when a judicial warrant and probable cause is required is not always apparent.

The questions here include the following: (1) May police go

(Oct. 19, 2001), in 51 AM. U. L. REV. 431, 442 (2002).

39. Edward J. Imwinkelried & D.H. Kaye, *DNA Typing: Emerging or Neglected Issues*, 76 WASH. L. REV. 413, 447-51 (2001).

40. E.g., Heather E. Collins-Schramm et al., *Mexican American Ancestry-Informative Markers: Examination of Population Structure and Marker Characteristics in European Americans, Mexican Americans, Amerindians and Asian*, 114 HUM. GENETICS 263 (2004); Mary-Anne Enoch et al., *Using Ancestry-Informative Markers to Define Populations and Detect Population Stratification*, 20 J. PSYCHOPHARMACOLOGY 19 (2006).

41. The commercial firm, DNAPrint, offers the following service to police agencies: “DNAWitness™ will provide the percentage of genetic make up amongst the four possible groups of Sub-Saharan African, Native American, East Asian, and European.” DNAPrint Home Page, <http://www.dnaprint.com/welcome/productsandservices/forensics/> (last visited Apr. 11, 2007). The company advertises that “We have performed about 13,000 ‘blind’ tests to date. For example, one west coast police department sent 16 samples collected from members of the department. The results were judged by them to be correct (consistent with phenotype and self-held notions of ancestry) for all 16 samples.” *Id.*

42. See generally Imwinkelried & Kaye, *supra* note 39.

43. U.S. CONST. amend. IV.

door-to-door, or car-to-car, canvassing for “voluntary” DNA samples but threatening individuals with becoming targets for further investigation if they refuse to cooperate? (2) May the state obtain tissue samples from medical providers without the knowledge or consent of the donor?⁴⁴ (3) If DNA is extracted without any bodily intrusion (for example, by following a suspect and collecting shed hairs or saliva from a beer mug at a bar), is there a search that must be justified under the Fourth Amendment? (4) May police trick a suspect into providing DNA, for example, by mailing the suspect a letter on law firm stationery saying he is eligible for money in a class-action lawsuit and then recovering saliva from the envelope containing the claim form?⁴⁵

Most of these practices have been undertaken, and lower courts have approved of some of them.⁴⁶ Certainly, some deception in interrogations⁴⁷ and the warrantless collection of “abandoned” possessions⁴⁸ are accepted with regard to acquiring other types of information in criminal investigations. To reach a different conclusion here would be to indulge in “genetics exceptionalism,” and that is precisely what some legal commentators have proposed.⁴⁹

44. There are reports that this was done in Wichita to see if Dennis Rader might be the notorious BTK killer. *See Readers Still Want Answers on BTK*, WICHITA EAGLE, July 3, 2005 (reporting that

In an effort to hide from Rader that they were zeroing in on him as a BTK suspect, investigators obtained a subpoena for his daughter's DNA from a tissue sample stored at a medical clinic in Kansas. It was processed within a week before Rader's arrest on Feb. 25. After Rader was arrested, authorities took a DNA sample from his daughter at her Michigan home to help confirm earlier test results.).

45. *See* Tracy Johnson, *Convicted Murderer Says Officers Broke Law with DNA Trick Police Ruse Case Argued*, SEATTLE POST-INTELLIGENCER REP., Jan. 27, 2006, at B1.

46. *E.g.*, *State v. Buckman*, 613 N.W.2d 463 (Neb. 2000) (defendant abandoned cigarette butt with saliva in police station).

47. *See, e.g.*, *Illinois v. Perkins*, 496 U.S. 292, 294 (1990) (“*Miranda* warnings are not required when the suspect is unaware that he is speaking to a[n undercover] law enforcement officer and gives a voluntary statement”).

48. *See* John P. Ludington, *Search and Seizure: What Constitutes Abandonment of Personal Property Within Rule That Search and Seizure of Abandoned Property Is Not Unreasonable—Modern Cases*, 40 A.L.R.4th 381 (1985).

49. Elizabeth E. Joh, *Reclaiming “Abandoned” DNA: The Fourth Amendment and Genetic Privacy*, 100 NW. U. L. REV. 857 (2006) (concluding that courts are unlikely to extend Fourth Amendment protection to “covert involuntary DNA sampling” but advocating a statutory requirement for a warrant).

C. DNA DATABASES

In addition to the traditional use of trace evidence to show the presence of a known suspect at a crime scene, all American states, the federal government, and many other countries have compelled convicted offenders to provide DNA samples for the creation of computer-searchable databases of their identifying profiles. These are used when there is no known suspect to test. There are over four million records in the FBI's National Database Index System (NDIS). The DNA records consist of the STRs at thirteen loci selected by the FBI for common use. The numbers are similar to passport or Social Security numbers in that they are essentially arbitrary strings of digits assigned by nature.⁵⁰

These databases help police to solve cases that have baffled them for decades and to catch previously convicted offenders who commit new crimes. In Virginia, there was the rapist who blew out a candle before attacking his victim. The candle had his saliva on it. There was the burglar who wore a pair of socks on his hands and left no fingerprints. But he left the socks that contained skin cells. There was the bank robber who dropped his ski mask. All were identified by checking the DNA profiles against the state's database of convicted felons.⁵¹

At the outset, privacy advocates maintained that sex-offender databases were just the camel's nose and the government would follow up with greatly expanded databases. They were correct. The trend is toward all-felons databases.⁵²

50. Professor Joh asserts that "some markers now thought to be meaningless may be (and have been) found to contain predictive medical information as the science progresses." *Id.* at 870. The basis for this claim is flimsy. None of the NDIS markers are known to be predictive or diagnostic of any medical condition. The news stories on which Professor Joh relies do not suggest otherwise. D.H. Kaye, *Science Fiction and Shed DNA*, 101 NW. U. L. REV. COLLOQUY 62 (2006).

51. *Profile: Use of a DNA Data Bank to Catch Criminals in Virginia*, (Nat'l Public Radio Morning Edition, Mar. 8, 2001), available at 2001 WL 9326731.

52. See, e.g., Amy Norton, *DNA Databases: The New Dragnet*, 19 THE SCIENTIST 50 (2005); Rick Weiss, *Vast DNA Bank Pits Policing vs. Privacy: Data Stored on 3 Million Americans*, WASH. POST, June 3, 2006, at A1 ("At least 38 states now have laws to collect DNA from people found guilty of misdemeanors, in some cases for such crimes as shoplifting and fortunetelling. At least 28 now collect from juvenile offenders, too."). The experience with expanded databases has greatly undermined the prediction of the first National Academy committee that "it is clear that crimes of most types will not afford the opportunity to recover relevant biological evidence that will allow the police to identify an unknown suspect—i.e., the

Furthermore, the individuals who might be implicated by DNA database searches are not necessarily limited to those whose samples are in the database.⁵³ When a Winston-Salem newspaper editor was raped and killed in 2003, the DNA trace did not fully match anything in the database, but one convicted offender was a near match. This similarity suggested that although the criminal whose DNA was on file was not the murderer, a sibling might be. Sure enough, detectives found that there was a brother. By following the brother, detectives were able to collect DNA evidence from saliva he left on discarded cigarette butts. His DNA proved to be a perfect match to the sample from the crime scene.⁵⁴ Does such “near-match searching” infringe any rights or exceed statutory authority, or is it simply a clever investigative practice?⁵⁵

Concerns also have been voiced with regard to the uses to which the DNA data and samples might be put.⁵⁶ Some bioethicists and law professors have claimed that the laws countenance research with offender records or samples in violation of the Nuremberg Code and the basic principle of medical ethics and human rights that forbids medical experimentation on human subjects.⁵⁷ The American Civil Liberties Union (ACLU) fears that the government will use the samples in a search “for a crime gene”⁵⁸

perpetrator’s own body fluids. They include larcenies, burglaries, and assaults” COMMITTEE ON DNA TECHNOLOGY IN FORENSIC SCIENCE, *supra* note 25, at 120.

53. See, e.g., Frederick R. Bieber et al., *Human Genetics: Finding Criminals Through DNA of Their Relatives*, 312 *SCIENCE* 1315 (2006); David R. Paoletti et al., *Assessing the Implications for Close Relatives in the Event of Similar But Nonmatching DNA Profiles*, 46 *JURIMETRICS J.* 161 (2006).

54. Richard Willing, *Suspects Get Snared by a Relative’s DNA*, *USA TODAY*, June 8, 2005, at A1. This proof of the brother’s guilt triggered the release from prison of Darryl Hunt, who had been imprisoned for the past eighteen years. *Id.*

55. The most thoughtful analysis of this question published to date is Henry T. Greely et al., *Family Ties: The Use of DNA Offender Databases to Catch Offenders’ Kin*, 34 *J. L. MED. & ETHICS* 248 (2006).

56. See D.H. Kaye, *Bioethics, Bench, and Bar: Selected Arguments in Landry v. Attorney General*, 40 *JURIMETRICS J.* 193 (2000).

57. Brief for Institute for Science, Law and Technology and Illinois Institute of Technology as Amici Curiae Supporting Appellee, *Landry v. Attorney General*, 709 N.E.2d 1085 (Mass. 1999) (No. SJC-07899).

58. Interview by Ira Flatow with Nadine Strossen, on National Public Radio Talk of the Nation, (May 25, 2001), available at http://www.sciencefriday.com/pages/2001/May/hour1_052501.html; see also

In my opinion, claims like these are grossly overstated. The kinds of research that are allowed are far less threatening than pawing through millions of personally identified samples for a mythical “crime gene.” The federal DNA Identification Act of 1994 limits research to “identification research and protocol development purposes,” and then only “if personally identifiable information is removed.”⁵⁹ The states must adhere to the same privacy protections if they are to receive federal funding for their forensic DNA laboratories.⁶⁰

Criminal DNA databases also prompt Fourth Amendment concerns.⁶¹ Several states have adopted laws to take DNA from people when they are merely brought into custody. With almost no publicity, President Bush signed comparable federal legislation into law.⁶² Almost without exception, courts have held that convicted offenders can be compelled to contribute their DNA without probable cause (or any sort of individualized suspicion) and without a warrant.⁶³ They have

Speeding DNA Evidence Processing: Hearing Before the Subcomm. on Crime of the H. Comm. on the Judiciary, 106th Cong. (2000) (testimony of Barry Steinhardt, Associate Director, American Civil Liberties Union, Washington, D.C.) (describing DNA samples as harboring our “most intimate secrets,” possibly including “genetic markers for aggression, substance addiction, criminal tendencies and sexual orientation”), available at 2000 WL 342540.

59. 42 U.S.C. § 14132(b) (2000).

60. For a more thorough analysis of the DNA database statutes, see D.H. Kaye, *Behavioral Genetics Research and Criminal DNA Databases*, 69 L. & CONTEMP. PROBS. 259 (2006).

61. Much of my discussion of this issue is contained in D. H. Kaye, *Who Needs Special Needs? On the Constitutionality of Collecting DNA and Other Biometric Data from Arrestees*, 34 J.L. MED. & ETHICS 188 (2006), which pursues the matter in greater depth.

62. Section 1004(a)(1)(A) of the DNA Fingerprint Act of 2005 amended the DNA Identification Act of 1994, 42 U.S.C. § 14132, by providing that “[t]he Attorney General may, as prescribed by the Attorney General in regulation, collect DNA samples from individuals who are arrested or from non-United States persons who are detained under the authority of the United States.” As codified, 42 U.S.C. § 14132(a) provides that

[t]he Director of the Federal Bureau of Investigation may establish an index of—(1) DNA identification records of—(A) persons convicted of crimes; (B) persons who have been charged in an indictment or information with a crime; and (C) other persons whose DNA samples are collected under applicable legal authorities, provided that DNA samples that are voluntarily submitted solely for elimination purposes shall not be included in the National DNA Index System.

63. See Robin Cheryl Miller, *Validity, Construction, and Operation of State DNA Database Statutes*, 76 A.L.R.5th 239 (2000); Richard P. Shafer, *Validity, Construction, and Application of DNA Analysis Backlog Elimination Act of 2000*, 42 U.S.C.A. §§ 14135 et seq. and 10 U.S.C.A. § 1565, 187 A.L.R. Fed. 373 (2003).

done so on two theories. The first theory looks to Supreme Court cases that dispense with the warrant requirement “when ‘special needs beyond the normal need for law enforcement, make the warrant and probable-cause requirement impracticable.’”⁶⁴ Certain programs of compulsory drug testing of federal employees, for example, have been upheld as reasonable because they serve the government’s special interest as an employer in reducing the use of drugs in its work force or in safeguarding the public with whom these employees deal.⁶⁵

However, the Supreme Court has cut back on this exception by blocking its extension to programs whose “primary purpose” is the enforcement of criminal law. For example, in *Ferguson v. City of Charleston*,⁶⁶ the Medical University of South Carolina began testing urine samples from pregnant patients for drugs to build criminal cases that would induce them to accept substance-abuse treatment. Because “the immediate objective of the searches was to generate evidence for law enforcement purposes,”⁶⁷ the Supreme Court held that the testing program could not be sustained under the special-needs doctrine.

The logic of the primary-purpose limitation is not entirely clear. It seems odd to maintain that the balance of interests permits dispensing with warrants or individualized suspicion when non-law enforcement interests alone are pursued, but not when both law enforcement and non-law enforcement interests reinforce each other. Be that as it may, the convicted-offender databases exist primarily to facilitate the identification of the perpetrators of sexual assaults, murders, and many other crimes. They have some secondary uses, such as identifying missing persons or disaster victims, but criminal investigation is their *raison d’être*.

Thus, the special-needs doctrine (as articulated in *Ferguson*) is a poor fit to DNA databases. Many courts therefore have taken a different tack. Without explaining why, they either have abandoned the notion that there needs

64. *Griffin v. Wisconsin*, 483 U.S. 868, 873 (1987) (quoting *New Jersey v. T.L.O.*, 469 U.S. 325, 351 (1985) (Blackmun, J., concurring)).

65. *E.g.*, *Skinner v. Railway Labor Executives’ Ass’n*, 489 U.S. 602 (1989).

66. 532 U.S. 67 (2001).

67. *Id.* at 83.

to be a categorical exception to the warrant requirement, or they have created a *sui generis* exception for DNA databases. These courts maintain that the DNA data are extremely useful in preventing and investigating crime, while the bodily intrusion is minimal, the personal information only reveals individual identity, and the individuals' status as a convicted criminal diminishes his privacy. In this way, they have upheld taking DNA after conviction.⁶⁸

Despite its popularity with the courts, a DNA-convicted-offender-only exception to the warrant requirement is unsatisfactory. Reasoning that a conviction works a perpetual forfeiture of Fourth Amendment protection is disturbing. I understand, of course, that convicts have a reduced expectation of privacy while they are incarcerated, but why is there a more permanent loss of privacy? Would we say that a man or woman who was once convicted of a crime but has long since completed the sentence has no claim to the protections of the Fourth Amendment? That the police are free to enter his home at their whim?

I propose dealing with the problem, not by diminishing the rights of convicted offenders, but by recognizing a new, well cabined "biometric identification exception" to the warrant requirement. Certain dicta suggest that the Supreme Court might uphold compulsory acquisition of biometric data from a person when (1) the process is not physically or mentally invasive, (2) the data are useful primarily to link individuals to crime scenes or to establish the true identity of a given individual, and (3) the data are valid, reliable, and effective for this purpose.⁶⁹ In these circumstances, harms to individuals and the benefits of judicial review are minor; hence, the balance between individual privacy and government interests points to the reasonableness of the collection and use of the identifying data without a judicial warrant. Practices such as taking fingerprints, mug-shots, and DNA even at the time of an arrest could be sustained under this exception.

The biometric exception also has the virtue of opening up public debate on the advisability of a population-wide database. If we wanted to start to build such a database, we could start now, as an addition to newborn screening programs. The police would not need to collect or store the samples. The resulting, comprehensive database—the records

68. Kaye, *supra* note 61, at 192.

69. *See id.* at 193.

of the essentially random digits in each person's DNA—would have a variety of advantages.⁷⁰ For example, the inclusive database could not be seen as disproportionately burdensome on minorities, who, for a variety of reasons, tend to be swept into the criminal justice system. According to the Bureau of Justice Statistics, about one in three black males, one in six Hispanic males, and one in seventeen white males will go to prison during their lifetime.⁷¹ If criminal databases mirror these disparities, they will add to the corrosive perception that the criminal justice system is stacked against African-Americans and other minorities.

In the end, perhaps a population-wide database is not desirable. I am not prepared to urge its implementation tomorrow. But its time may come. Then the challenge will be to construct it so as to enhance public order and security while respecting legitimate individual privacy rights. The double helix is not only an icon of the “molecule of life.” It also is a metaphor for the intertwining of genetics and the law.

CONCLUSION

The science of human DNA identification has matured greatly since its exuberant introduction in the late 1980s. After years of bitter debates about laboratory techniques, statistics, and population genetics, the admissibility of properly conducted DNA tests of highly variable loci is no longer in question. Along with this successful courtroom implementation of DNA identification technology have come increasingly aggressive uses of DNA in investigating crimes. These developments have attracted the attention of bioethicists and civil-liberties advocates. In evaluating the expansion of DNA databases for law enforcement and other uses of the forensic science, however, it cannot be assumed that all the norms that are accepted and valuable in the context for biomedical *research* with human *subjects* necessarily are appropriate in the context of forensic *investigation* with human *suspects*. Establishing reasonable

70. See D.H. Kaye & Michael E. Smith, *DNA Identification Databases: Legality, Legitimacy, and the Case for Population-Wide Coverage*, 2003 WIS. L. REV. 413 (2003).

71. Thomas P. Bonczar, Bureau of Justice Statistics, *Prevalence of Imprisonment in the U.S. Population, 1974-2001* (2003), available at <http://www.ojp.usdoj.gov/bjs/abstract/piusp01.htm>.

limits on the technological imperative requires an appreciation and understanding of the law of criminal procedure, the costs and benefits of the techniques, and the political and ethical principles that foster a free society of autonomous individuals. This brief review of history and current issues does not answer the question of how far the technology of DNA identification should be carried, but it does reveal that the question cannot be ignored.