Allowing New Technology to Erode Constitutional Protections: A Fourth Amendment Challenge to Non-Consensual DNA Testing of Prisoners

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ALLOWING NEW TECHNOLOGY TO ERODE CONSTITUTIONAL PROTECTIONS: A FOURTH AMENDMENT CHALLENGE TO NON-CONSENSUAL DNA TESTING OF PRISONERS
Jones v. Murray (1992)

I. INTRODUCTION

Officials charged with enforcing the criminal laws need effective ways to identify suspects.1 Forensic DNA testing provides a powerful new tool with which to do so.2 DNA is the “basic material of heredity” that determines the biological characteristics of the individual.3 In criminal investigations, DNA testing enables law enforcement officials to compare test results from a suspect’s DNA with those from DNA detected in evidence, such as blood-stained clothing found at a crime scene.

1. WAYNE R. LAFAVE & JEROLD H. ISRAEL, CRIMINAL PROCEDURE § 7.1, at 353 (2d ed. 1999) (“The identification problem is a serious one and has long existed.”). As early as the turn of the century, a portion of the law of evidence was devoted to rules of identification. See GEORGE E. HARRIS, A TREATISE ON THE LAW OF IDENTIFICATION 1 (Albany, H.B. Parsons 1892) (asserting that law of identification was “a question of growing importance and one that is daily before the courts”).


(1617)
scene. A match between the results from the two tested samples constitutes evidence that the suspect committed the crime.4 One method for law enforcement officials to obtain a suspect’s blood for DNA testing is to secure a search warrant.5 In addition, a number of states have created databases of DNA test results from persons convicted of particular crimes for later comparison with test results from DNA found in crime scene evidence.6 When state authorities take blood samples from incar-

4. See, e.g., Colorado v. Lindsey, No. 90-CA0556, 1993 WL 2650, at *1 (Colo. Ct. App. Jan. 7, 1993). In Lindsey, the court described the DNA testing and identification at issue in a rape and burglary case:

Blood samples from defendant and the two victims, together with vaginal swabs taken from the two victims shortly after the assaults, were sent to Cellmark Diagnostic Corporation. Cellmark subsequently reported that the DNA (deoxyribonucleic acid) from known blood of the defendant matched the DNA “fingerprint” of the samples obtained from the vaginal swabs of the two victims and a semen stain sample from the bedsheets recovered after the January incident.

Id. This “match” was admitted as evidence that the defendant was the source of the semen and therefore the perpetrator of the crime. Id. at *3 (noting that all other evidence against defendant was circumstantial); see United States v. Porter, 618 A.2d 629, 630 (D.C. 1992) (“The DNA evidence was thus intended to corroborate the complainant’s expected identification of Porter as her assailant and to demonstrate that it was extremely improbable that someone other than Porter had committed the crime.”).


cerated felons without their consent in order to create these databases, a question arises as to whether the testing violates Fourth Amendment protection against unreasonable searches.\footnote{7}

In Jones v. Murray\footnote{8} the United States Court of Appeals for the Fourth Circuit became the first appellate court to address this question.\footnote{9} In Jones, the court held that a Virginia statute authorizing non-consensual DNA testing of incarcerated felons\footnote{10} did not violate the Fourth Amendment of the United States Constitution.\footnote{11} The Jones court con-

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\footnote{7} See U.S. Const. amend. IV ("The right of the people to be secure in their persons . . . against unreasonable searches and seizures, shall not be violated."). The United States Supreme Court has held that a blood test is a search under the Fourth Amendment; as such, the state must demonstrate its reasonableness. Schmerber v. California, 384 U.S. 757, 771-72 (1966).


\footnote{9} Id. at 306. For a detailed discussion of the reasoning of Jones, see infra notes 165-210 and accompanying text.

\footnote{10} Va. Code Ann. §§ 19.2-310.2 to .7 (Michie Supp. 1993). The statute states, in pertinent part:

Every person convicted of a felony on or after July 1, 1990, and every person convicted of [felony criminal sexual assault] . . . who was incarcerated on July 1, 1989, shall have a sample of his blood taken for DNA (deoxyribonucleic acid) analysis to determine identification characteristics specific to the person. . . . The identification characteristics of the profile resulting from the DNA analysis shall be stored and maintained . . . in a DNA data bank and shall be made available only as provided in § 19.2-310.5.

\textit{Id.} § 19.2-310.2.

Subsequent subsections of the statute outline DNA analysis and database procedures including: 1) withdrawal of the blood sample, 2) conducting the DNA analysis on the sample, 3) maintenance of the resulting database and 4) exchanging information on request of law enforcement officials. \textit{Id.} § 19.2-310.3 to .5. The statute also provides penalties for unauthorized use of the database samples and information, and a procedure for expungement of a DNA profile if the felony conviction, which provided the basis for including the information, is reversed and the case dismissed. \textit{Id.} § 19.2-310.6 to .7.

\footnote{11} Jones, 962 F.2d at 310. For a detailed discussion of the reasoning of the majority and the points of departure of the dissent, see infra notes 165-210. In Jones, six prisoner-plaintiffs brought an action challenging the constitutionality of the Virginia compulsory DNA testing statute under 42 U.S.C. § 1983. Jones, 962 F.2d at 305. The prisoner-plaintiffs brought the action against the Director of the Virginia Department of Corrections and the Director of the Bureau of Forensic Science. \textit{Id.} They alleged that the blood tests authorized by the statute constituted unreasonable searches prohibited by the Fourth Amendment and that the statute operated as an ex post facto law in violation of the Eighth Amendment. \textit{Id.} On cross motions for summary judgment, the United States
cluded that the Fourth Amendment offers little or no protection to the privacy interests of prisoners and that even if such interests are protected, state interests in solving future crimes outweigh the minor intrusion represented by taking blood samples for DNA analysis.\(^\text{12}\)

In order to provide a background for analyzing the constitutionality of non-consensual DNA testing, this Note first sets forth the basic Fourth Amendment principles relevant to the analysis.\(^\text{13}\) After placing blood tests as searches in Fourth Amendment context,\(^\text{14}\) this Note reviews two relevant lines of United States Supreme Court precedent interpreting the Fourth Amendment: cases determining the level of Fourth Amendment protection prisoners retain while incarcerated,\(^\text{15}\) and cases addressing the reasonableness under the Fourth Amendment of searches conducted without individualized suspicion.\(^\text{16}\) As a model, this Note also discusses one case that applied the Fourth Amendment framework provided by these two lines of cases to non-consensual blood-testing of prisoners.\(^\text{17}\) Next, this Note examines how the technology, reliability and admissibility of DNA testing may alter this Fourth


On appeal, the United States Court of Appeals for the Fourth Circuit affirmed the greater part of the district court's ruling. \textit{Jones}, 962 F.2d at 310-11. The Fourth Circuit held that the language in the statute that purported to make it apply irrespective of the Virginia mandatory parole statute had the effect of an unconstitutional ex post facto law. \textit{Id.} at 311. As to this conclusion there was no dissent. \textit{Id.} (Murnaghan, J., concurring in part and dissenting in part).

12. \textit{Jones}, 962 F.2d at 310-11. The Jones court summarized its holding in the following terms:

\begin{quote}
Considering the inmates' questionable claim of privacy to protect their identification and the minimal intrusion resulting from taking a small sample of blood, the Commonwealth's interest in combatting and deterring felony recidivism justifies the involuntary taking of the sample and the creation of the DNA database as reasonable in the context of the Fourth Amendment. \textit{Id.}
\end{quote}

For a detailed discussion of the majority's reasoning and the dissent's points of departure, see infra notes 165-210 and accompanying text.

13. For the complete discussion of Fourth Amendment cases bearing on the constitutionality of non-consensual blood tests, see infra notes 20-85 and accompanying text.

14. For a complete discussion of the status of blood tests as Fourth Amendment searches, see infra notes 20-85 and accompanying text. In addition, for another student perspective on the place of \textit{Jones v. Murray} in the context of the Supreme Court's Fourth Amendment jurisprudence, see Michael W. Kier, Comment, \textit{Jones v. Murray: Allowing the Government to Get Blood From a Stone}, 42 \textit{CASE W. RES. L. REV.} 635 (1992).

15. For a full discussion of the prisoners' rights cases, see infra notes 38-53 and accompanying text.

16. For a detailed discussion of the suspicionless search cases, see infra notes 54-75 and accompanying text.

17. For a complete discussion of this case, Dunn v. White, 880 F.2d 1188, 1194-97 (10th Cir. 1989), cert. denied, 493 U.S. 1059 (1990), see infra notes 77-85 and accompanying text.
Amendment framework.\(^{18}\) Finally, this Note analyzes the Jones court's resolution of the constitutionality of non-consensual blood testing of prisoners for DNA identification and concludes that the rule set forth in Jones unduly curtails the privacy rights of non-violent felons.\(^{19}\)

II. BACKGROUND

A. United States Supreme Court Fourth Amendment Jurisprudence Leading Up to Jones

1. Blood Testing in a Fourth Amendment Context

The Fourth Amendment to the United States Constitution protects "the people" against unreasonable searches and seizures by the government.\(^{20}\) In Katz v. United States,\(^{21}\) the United States Supreme Court defined a "search" for the purposes of Fourth Amendment analysis as a governmental intrusion into an area where an individual has a "reasonable expectation of privacy."\(^{22}\) Accordingly, in every Fourth Amendment case, the interest of the government must be balanced against the competing interest of the individual.\(^{23}\) In 1966, the Supreme Court first examined these interests in the context of a non-consensual blood test

\(^{18}\) The consideration of DNA testing in this Note consists of four sections: 1) the scientific theory and procedures underlying DNA analysis, 2) the procedural sources of error in DNA testing, 3) the debate regarding the statistical underpinnings of DNA identification evidence and 4) the admissibility of DNA identification evidence once obtained. For a description of forensic DNA testing procedures, see infra notes 90-106 and accompanying text. For a discussion of laboratory competence issues, see infra notes 109-12 and accompanying text. For a discussion of the debate regarding the statistical issues effecting the reliability of DNA test results, see infra notes 113-20 and accompanying text. For a discussion of the different standards used by various courts in deciding the admissibility of DNA identification evidence, see infra notes 121-42 and accompanying text. In order to present a complete picture of the value of DNA identification evidence, this Note also considers the privacy concerns generated by DNA testing and particular issues raised by the creation of databases of DNA identification information. See infra notes 143-64 and accompanying text.

\(^{19}\) For a complete discussion of the Jones court's reasoning, see infra notes 165-92. For a discussion of the potentially detrimental effect of Jones on the Fourth Amendment rights of non-violent felons, see infra notes 230-34.

\(^{20}\) U.S. Const. amend. IV ("The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated.").


\(^{22}\) Id. at 360-61 (Harlan, J., concurring) (holding that physical or electronic intrusion into area where one has reasonable expectation of privacy is "search" in constitutional terms and is presumptively unreasonable unless conducted pursuant to search warrant).

\(^{23}\) Skinner v. Railway Labor Executives' Ass'n, 489 U.S. 602, 619 (1989) (reasonableness "of a particular practice 'is judged by balancing its intrusion on the individual's Fourth Amendment interests against its promotion of legitimate governmental interests' " (quoting Delaware v. Prouse, 440 U.S. 648, 654 (1979))).
in Schmerber v. California.\textsuperscript{24}

In Schmerber, the Supreme Court noted that a blood test implicates “interests in human dignity and privacy” protected by the Fourth Amendment.\textsuperscript{25} The Court applied the Katz definition of a “search” and held that a non-consensual blood test was a Fourth Amendment search.\textsuperscript{26} In 1989, the Court reiterated this principle in Skinner v. Railway Labor Executives’ Ass’n\textsuperscript{27} stating that “it is obvious that this physical intrusion, penetrating beneath the skin, infringes an expectation of privacy that society is prepared to recognize as reasonable.”\textsuperscript{28}

Regarding the degree of government suspicion required for a blood test to be a reasonable search, the Schmerber Court noted that “the Fourth Amendment . . . forbid[s] any such intrusion[] on the mere chance that desired evidence might be obtained.”\textsuperscript{29} Although the Schmerber Court considered a blood test to be a relatively minor intrusion on the suspect’s privacy,\textsuperscript{30} the Court suggested that ordinarily the Fourth Amendment would require a search warrant for any non-consensual blood test.\textsuperscript{31} Nevertheless, the Schmerber Court held that the blood test at issue fulfilled constitutional requirements despite having been performed without either a warrant or probable cause because emergency circumstances existed.\textsuperscript{32}

\textsuperscript{24} Schmerber v. California, 384 U.S. 757, 767 (1966). In Schmerber, the Court held that a warrantless blood-alcohol test of a person arrested on probable cause did not violate the Fourth Amendment. \textit{Id.} at 772. The Court noted that under the circumstances the officer could reasonably believe that the alcohol would dissipate from the suspect’s blood stream before a warrant could be obtained. \textit{Id.} at 770.

\textsuperscript{25} \textit{Id.} at 769-70.

\textsuperscript{26} \textit{Id.} at 770.


\textsuperscript{28} \textit{Id.} at 616 (citing Schmerber v. California, 384 U.S. 757, 767-68 (1966)).

\textsuperscript{29} Schmerber, 384 U.S. at 770.

\textsuperscript{30} \textit{Id.} at 771. “Such tests are a commonplace in these days of periodic physical examinations and experience with them teaches that the quantity of blood extracted and experience with them teaches that the quantity of blood extracted is minimal, and that for most people the procedure involves virtually no risk, trauma, or pain.” \textit{Id.} (footnote omitted). The Schmerber Court also cautioned that its holding that the Fourth Amendment permitted blood tests “under stringently limited conditions” did not mean either that greater intrusions would be permitted or that blood tests would be permitted in other circumstances. \textit{Id.} at 772. The Court identified one such “other circumstance” in Winston v. Lee, 470 U.S. 753, 755 (1985), which held that surgery under general anesthetic to retrieve a bullet lodged in a suspect’s chest was an unreasonable search prohibited by the Fourth Amendment.

\textsuperscript{31} Schmerber, 384 U.S. at 770 (“Search warrants are ordinarily required for searches of dwellings, and, absent an emergency, no less could be required where intrusions into the human body are concerned.”).

\textsuperscript{32} \textit{Id.} at 770 (“The officer in the present case, however, might reasonably have believed that he was confronted with an emergency” because alcohol would disappear from suspect’s blood before warrant could be obtained.). The Court also noted that a blood test was a relatively minor intrusion on the suspect’s privacy and that the test was performed in a “hospital environment according to accepted medical practices.” \textit{Id.} at 771.
In addition to the Schmerber analysis of non-consensual blood testing, two lines of Supreme Court cases interpreting the Fourth Amendment are also relevant in determining the reasonableness of non-consensual DNA testing of prisoners: prisoners' rights cases and suspicionless search cases. Cases dealing with the Fourth Amendment rights of prisoners are apposite because the subjects of the DNA testing in Jones were convicted felons and because the Supreme Court has recognized that the constitutional rights of prisoners are necessarily altered by the fact of their incarceration. Similarly, cases dealing with the degree of individualized suspicion, if any, required to satisfy the Fourth Amendment reasonableness standard are of interest because the DNA testing at issue in Jones was conducted in the absence of any individualized suspicion whatsoever.

2. Prisoners' Rights Cases

Although prisoners retain some constitutional rights while incarcerated, the extent of their retained protection under the Fourth Amendment

33. For a discussion of cases concerning the Fourth Amendment rights of prisoners, see infra notes 38-53 and accompanying text.
34. For a discussion of cases concerning circumstances under which the Fourth Amendment permits searches conducted without individualized suspicion, see infra notes 54-75 and accompanying text.
35. Jones, 962 F.2d at 304 (noting that Virginia law being challenged subjected all convicted felons to non-consensual DNA testing).
36. Bell v. Wolfish, 441 U.S. 520, 545 (1979) ("[C]onvicted prisoners do not forfeit all constitutional protections by reason of their conviction and confinement in prison."); see Meachum v. Fano, 427 U.S. 215, 225 (1976) (reaffirming that "the convicted felon does not forfeit all constitutional protections by reason of his conviction"); Wolff v. McDonnell, 418 U.S. 539, 555-56 (1974) ("There is no iron curtain drawn between the Constitution and the prisons of this country.").

However, the Court has just as consistently recognized that incarceration does curtail prisoners' Fourth Amendment rights. Bell, 441 U.S. at 545-46 ("The fact of confinement as well as the legitimate goals and policies of the penal institution limits [their] retained constitutional rights."); see Hudson v. Palmer, 468 U.S. 517, 523-24 (1984) (noting that "we have insisted that prisoners be accorded those rights not fundamentally inconsistent with imprisonment itself or incompatible with the objectives of incarceration" and briefly discussing series of cases defining prisoners' retained rights under various aspects of First, Fifth and Eighth Amendments).
37. Jones, 962 F.2d at 313 (Murnaghan, J., dissenting) ("As both parties concede, the DNA testing involved in the present case [was] not based upon any individualized suspicion of the persons tested . . ."). For a discussion of the suspicionless search cases, see infra notes 54-75.
ment is exceedingly small. For example, in *Bell v. Wolfish*, the Court held that routine visual body cavity searches of pretrial detainees were not unreasonable searches under the Fourth Amendment. The *Bell* Court articulated four principles derived from previous cases that guided its analysis. First, the Court acknowledged that prisoners do not lose all constitutional protections simply because they are incarcerated. Second, the Court reiterated that incarceration nonetheless limits those retained protections. Third, the Court emphasized that institutional security, a prison's central goal, could also limit prisoners' retained constitutional rights. Fourth, the Court observed that prison officials require "wide-ranging deference in the adoption and execution of policies and practices" to maintain institutional security.

Using these four principles, the *Bell* Court determined the constitutionality of visual body cavity searches of pretrial detainees by applying a balancing test. The Court balanced the government's interests in maintaining institutional security and controlling contraband in the

38. See generally *Hudson*, 468 U.S. at 526 (holding suspicionless searches of prisoners' cells reasonable under Fourth Amendment); *Bell*, 441 U.S. at 558 (upholding body cavity searches of pretrial detainees); Dunn v. White, 880 F.2d 1188, 1194-97 (10th Cir. 1989) (upholding non-consensual blood tests of prisoners to detect HIV infection under Fourth Amendment), *cert. denied*, 493 U.S. 1059 (1990).


40. *Id.* at 558. *Bell* was a class action suit brought by pretrial detainees to challenge the practices and conditions at a federal short-term facility located in New York City. *Id.* at 523. One challenged procedure required that a visual body cavity search be conducted as part of a strip search after every contact visit between any prisoner and a person from outside the institution. *Id.* at 558. The purpose for the searches was to discover and deter smuggling of contraband or weapons into the prison. *Id.* Although the United States Court of Appeals for the Second Circuit held that this procedure violated the Fourth Amendment prohibition of unreasonable searches, the Supreme Court disagreed. *Id.*

41. *Id.* at 545-48.

42. *Id.* at 545. The Court cited several examples of prisoners' retained constitutional rights including freedom of speech, freedom of religion and freedom from invidious racial discrimination. *Id.* (citing *Pell v. Procunier*, 417 U.S. 817 (1974) (limitations on freedom of speech and press); *Cruz v. Beto*, 405 U.S. 319 (1972) (freedom of religion); *Lee v. Washington*, 390 U.S. 333 (1968) (segregation); *Cooper v. Pate*, 378 U.S. 546 (1964) (freedom of religion)).

43. *Id.* at 545-46 ("The fact of confinement as well as the legitimate goals and policies of the penal institution limits [sic] these retained constitutional rights." (citations omitted)).

44. *Id.* at 546-47 ("[E]ven when an institutional restriction infringes a specific constitutional guarantee, . . . the practice must be evaluated in the light of the central objective of prison administration, safeguarding institutional security." (citations omitted)).

45. *Id.* at 547. The Court cited two reasons for this judicial deference: 1) prison officials' expertise and experience normally make them better able to judge the necessity and appropriateness of a given procedure and 2) the Constitution places the operation of prisons in the legislative and executive branches of the government, not the judiciary. *Id.* at 547-48.

46. *Bell*, 441 U.S. at 559-60.
prison against the prisoners' privacy interests and concluded that the
government's interests prevailed. The Bell Court stated that courts
"must consider the scope of the particular intrusion, the manner in
which it is conducted, the justification for initiating it, and the place in
which it is conducted" as important factors when performing such
Fourth Amendment analysis.

Five years later, the Supreme Court went beyond Bell in Hudson v.
Palmer and held that a prisoner has no reasonable expectation of pri-
vacy in his or her cell, so that the intrusion in that case did not even
amount to a "search" under the Fourth Amendment. To justify its
position, the Hudson Court stated that "[t]he recognition of privacy
rights for prisoners in their individual cells simply cannot be reconciled
with the concept of incarceration and the needs and objectives of penal
institutions." Like the Bell Court, the Hudson Court employed a bal-
ancing test in its Fourth Amendment analysis and weighed the prison-
ers' interests in the privacy of their cells against society's interest in
prison security. The Hudson court concluded that the prisoners' ass-
serted expectation of privacy was unreasonable.

Prisoners' rights cases suggest considerations for the Fourth
Amendment analysis of non-consensual blood tests performed on pris-
oners in order to create databases of DNA test results. These consid-

47. Id.
48. Id. at 559 (citing several Fourth Amendment cases including United
States v. Martinez-Fuerte, 428 U.S. 543 (1976) and Schmerber v. California, 384
U.S. 757 (1966)). The Court expressly did not concern itself with the effective-
ness of the visual body cavity searches in promoting their intended ends. Id.
The Court pointed to evidence in the record and in other cases that these
searches had been productive elsewhere and did not treat as significant the fact
that only one such search at the prison in question had revealed contraband. Id.
49. Hudson v. Palmer, 468 U.S. 517 (1984). Hudson was an action by Rus-
sell Thomas Palmer, Jr., a pro se prisoner-plaintiff, under 42 U.S.C. § 1983. Id.
at 519-20. Palmer argued that a random, "shakedown" search of his prison cell
had violated his constitutional rights. Id.
50. Id. at 525-26 (holding that "shakedown search" of prison cell did not
amount to Fourth Amendment "search"). The Court reasoned that because so-
society does not recognize as reasonable any subjective expectation of privacy a
prisoner may have in his or her cell, "the Fourth Amendment proscription
against unreasonable searches does not apply within the confines of the prison
cell." Id. at 526.
51. Id. The Court noted that prison administrators must protect the safety of
prison personnel, visitors and the prisoners themselves by controlling weapons
and other contraband and that they must also preserve a sanitary prison
environment. Id. The Court asserted that it would be impossible to accomplish
these objectives if prisoners retained a right of privacy in their cells. Id. at 527.
52. Id. at 527 ("Determining whether an expectation of privacy is 'legiti-
mate' or 'reasonable' necessarily entails a balancing of interests.").
53. Id. at 527-28. The Hudson Court struck the required balance "in favor
of institutional security," noting its central importance in the prison setting. Id.
at 527. In its balancing, the Court also noted that the prisoner's privacy interest
was "already limited by the exigencies of the circumstances" and that society's
interest in prisoner security was "paramount." Id. at 527-28.
tions include whether a prisoner has any reasonable expectation of privacy at all in the area being searched and whether the search serves important government penal interests. Similarly, Supreme Court cases concerning whether the Fourth Amendment permits searches conducted without individualized suspicion also suggest factors that may affect the Fourth Amendment analysis of the constitutionality of such non-consensual blood tests.

3. Cases Addressing Searches Conducted Without Individualized Suspicion

State officials perform DNA identification analysis on prisoners' blood not because they suspect any prisoner of having committed unsolved past crimes, but rather because of the possibility that any prisoner may commit future crimes. The search represented by this blood testing is therefore conducted without any suspicion directed at the subject as an individual. Although the Supreme Court has not yet addressed the constitutionality of suspicionless DNA testing, it has considered the Fourth Amendment implications of similar suspicionless searches in other contexts.

The most important suspicionless search case to date is Skinner v. Railway Labor Executives' Ass'n. In Skinner, the Court refused to make individualized suspicion a per se requirement for reasonableness under the Fourth Amendment. Instead, to determine the degree of individualized suspicion required in order to justify mandatory railroad employee drug-testing under the Fourth Amendment, the Court applied the "special needs" test. Under the "special needs" test, if the go-

54. Jones v. Murray, 962 F.2d 302, 305 (4th Cir.) ("[T]he collection of blood samples [to create a DNA database] is designed to solve future cases for which no present suspicion can exist."); cert. denied, 113 S. Ct. 472 (1992).

55. Id.

56. Skinner v. Railway Labor Executives' Ass'n, 489 U.S. 602 (1989). In Skinner, the Supreme Court upheld Federal Railroad Administration regulations which mandated drug testing, including both blood and urine tests, of railroad employees involved in particular types of train accidents as not violative of the Fourth Amendment. Id. at 606, 634.

57. The Skinner Court stated: "In limited circumstances, where the privacy interests implicated by the search are minimal, and where an important governmental interest furthered by the intrusion would be placed in jeopardy by a requirement of individualized suspicion, a search may be reasonable despite the absence of such suspicion." 489 U.S. at 624. The Court reiterated this position in National Treasury Employees Union v. Von Raab:

While we have often emphasized . . . that a search must be supported, as a general matter, by a warrant issued upon probable cause . . . our decision in [Skinner] reaffirms the longstanding principle that neither a warrant nor probable cause, nor, indeed, any measure of individualized suspicion, is an indispensable component of reasonableness in every circumstance.


58. Skinner, 489 U.S. at 619 (quoting Griffin v. Wisconsin, 483 U.S. 868, 873 (1987)). In Griffin the Court defined the "special needs" test as follows: when
The government can show a need beyond the ordinary needs of law enforcement, the court will balance the individual's privacy expectations against the competing government interests to determine whether the Fourth Amendment requires a warrant or probable cause to justify the search at issue.59

The Skinner Court held that the Fourth Amendment required neither a warrant60 nor any degree of individualized suspicion to justify the drug-testing searches at issue.61 This conclusion rested in part on the Court's finding that railroad employees have a diminished expectation of privacy by virtue of their participation in an industry pervasively regulated to ensure safety.62 The Court also applied the "special needs" test to balance the governmental and privacy interests to determine whether a requirement of a warrant and/or probable cause is practicable in the particular context. 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)). The Skinner Court noted that in prior cases it had identified several such "special needs." Skinner, 489 U.S. at 619-20 (citing Griffin, 483 U.S. at 873-74 (operation of state probation system); New York v. Burg, 482 U.S. 691, 699-703 (1987) (regulation of certain businesses where regulatory scheme serves substantial government interest); O'Connor v. Ortega, 480 U.S. 709, 721-25 (1987) (operation of public hospital); T.L.O., 469 U.S. at 337-42 (operation of school); Bell v. Wolfish, 441 U.S. 520, 558-60 (1979) (operation of prison)). The Skinner Court held that the need to ensure safety by regulating the conduct of railroad employees constituted a "special need" that justified examining the utility of the warrant requirement in this context. Id. at 620.

59. Skinner, 489 U.S. at 619 ("When faced with such special needs, we have not hesitated to balance the governmental and privacy interests to assess the practicality of the warrant and probable-cause requirements in the particular context." (citing Griffin, 483 U.S. at 873)). The Skinner Court concluded that the government's compelling interest in safety outweighed the employees' privacy interests, and the regulations therefore did not violate the Fourth Amendment. Id. at 633; see National Treasury Employees Union v. Von Raab, 489 U.S. 656, 665-66 (1989) (using "special needs" test to find that drug testing of certain Customs Department employees did not violate Fourth Amendment).

60. Skinner, 489 U.S. at 619-24. The Court reasoned that a warrant ordinarily assures the citizen that the intrusion was objectively determined to be authorized by law and limited in scope. Id. at 622. Because the regulations in question were narrowly drawn to minimize discretion in enforcement, they adequately served this interest. Id. The Court also noted that requiring a warrant would effectively frustrate the government interest involved by allowing the drugs to dissipate from the employees' blood streams before they could be tested. Id. at 623; accord Schmerber v. California, 384 U.S. 757, 770-71 (1966) (finding exigent circumstances based in part on dissipation of alcohol from suspect's bloodstream). After balancing the governmental and individual privacy interests, the Skinner Court concluded that the Fourth Amendment did not require a warrant to justify these drug tests. Skinner, 489 U.S. at 624.

61. Skinner, 489 U.S. at 633. The Court reasoned that the government interest in determining employee responsibility for accidents and the difficulty of identifying signs of impairment in the aftermath of an accident outweighed the employees' reduced expectations of privacy in a pervasively regulated industry. Id. Consequently, the Court held that the Fourth Amendment did not require probable cause to justify these drug tests. Id.

62. Id. at 627-28 ("[T]he covered employees had] long been a principal
needs” test in National Treasury Employees Union v. Von Raab, decided the same day as Skinner. Taken together, Skinner and Von Raab establish satisfaction of the “special needs” test as one manner in which a search conducted without individualized suspicion may nevertheless satisfy the requirements of the Fourth Amendment.

The Supreme Court has also decided several cases concerning automobile checkpoints that address the degree of individualized suspicion, if any, required to justify such a seizure under the Fourth Amendment. For example, in Michigan Department of State Police v. Sitz, the Court used a balancing test to determine the reasonableness of an unannounced sobriety checkpoint. In holding that the checkpoint was a reasonable seizure, the Sitz Court balanced “the State's interest in preventing drunken driving [and] the extent to which [the] system [of checkpoints]

focus of regulatory concern.”); see Von Raab, 489 U.S. at 672 (“Unlike most private citizens or government employees in general, employees involved in drug interdiction reasonably should expect effective inquiry into their fitness and propriety.”). The Skinner Court noted, however, that the privacy expectations of employees in a pervasively regulated industry will not always be considered minimal. Skinner, 489 U.S. at 628.

64. Id. at 665 (noting use of “special needs” test in Skinner). The Court noted that “the traditional probable-cause standard may be unhelpful in analyzing the reasonableness of routine administrative functions.” Id. at 668 (citing Colorado v. Bertine, 479 U.S. 367, 371 (1987)).
67. Id. at 455. The State of Michigan established a pilot sobriety checkpoint program and conducted the checkpoint at issue in Sitz during a single one hour and fifteen minute operation in which 126 vehicles were briefly stopped and their drivers questioned. Id. at 448. The state police delayed each vehicle an average of 25 seconds. Id. The checkpoint program was challenged the day before it went into operation by a number of “licensed driver[s] in the State of Michigan . . . who regularly travel[] throughout the State” by automobile who sought declaratory and injunctive relief. Id. During pretrial proceedings, the State agreed to suspend the checkpoint operation until the litigation was finally decided. Id.
68. Id. at 450 (“Petitioners concede, correctly . . . , that a Fourth Amendment 'seizure' occurs when a vehicle is stopped at a checkpoint.”). In addition to noting the petitioners' concession that a checkpoint amounts to a seizure, the Sitz Court cited Brower v. City of Inyo, 489 U.S. 593 (1989) in support of its position. Id. In Brower the Court defined a “seizure” in Fourth Amendment terms as occurring “only when there is a governmental termination of freedom of movement through means intentionally applied.” Brower, 489 U.S. at 597 (emphasis in original) cited in Sitz, 496 U.S. at 450. The Fourth Amendment protects the people “against unreasonable searches and seizures.” U.S. Const. amend. IV. Reasonableness is thus the touchstone of Fourth Amendment analysis, and the Court uses similar balancing tests to determine the reasonableness of both searches and seizures. See 1 JOHN WESLEY HALL, SEARCH AND SEIZURE § 1:19 (2d. ed. 1991).
could] reasonably be said to advance that interest, [against] the degree of intrusion upon individual motorists." The Court held that the highway sobriety checkpoint program at issue was a reasonable seizure under the Fourth Amendment.70

The Court had used a similar balancing test earlier in United States v. Martinez-Fuerte71 in which it held that permanent immigration checkpoints set up to detect the transportation of illegal aliens did not violate the Fourth Amendment.72 In Martinez-Fuerte, the Court analogized to prior traffic-checking cases in order to establish that a balancing test was appropriate to evaluate the reasonableness of such stops as seizures under the Fourth Amendment.73 The Court then balanced the public

69. Sitz, 496 U.S. at 455. The Court derived the balancing test used in Sitz from balancing tests used in two prior cases. Id. at 448-50 (citing Brown v. Texas, 443 U.S. 47 (1979) and United States v. Martinez-Fuerte, 428 U.S. 543 (1976)). The Court rejected the lower court's interpretation of "the degree to which the seizure advances the public interest" prong as requiring an examination of the checkpoints' "effectiveness" in deterring drunk driving. Id. at 453-55.

The Court identified the individual privacy interest being weighed as including the motorists' "fear and surprise" at being stopped. Id. at 452. The Court found that the Michigan courts had consequently over-valued the motorists' privacy interests by giving too much weight to this fear and surprise. Id. The Court held that the proper balancing factor consisted of only the "fear and surprise engendered in law abiding motorists by the nature of the stop." Id. Recharacterized in this way, the Court concluded that the extremely brief stop, even while accounting for the motorists' fear and surprise, was a minor intrusion. Id. at 452-53.

Against this minor intrusion, the Court balanced the governmental interest in establishing the checkpoint program. Id. at 453. The Court emphasized that the question of whether a particular law enforcement strategy reasonably advances the government interest does not include an inquiry into the strategy's effectiveness. Id. at 453-54. The Court emphasized that this factor "was not meant to transfer from politically accountable officials to the courts the decision as to which among reasonable law enforcement techniques should be employed to deal with a serious public danger.... [T]he choice among ... reasonable alternative [law enforcement techniques] remains with the government officials." Id.

70. Id. at 455.
72. See id. at 566. Martinez-Fuerte concerned stops of illegal aliens made at permanent immigration checkpoints located on highways near the Mexican border based upon no "articulable suspicion." Id. at 547. The Supreme Court reversed the decision of the United States Court of Appeals for the Ninth Circuit that "a stop for inquiry is constitutional only if the Border Patrol reasonably suspects the presence of illegal aliens on the basis of articulable facts." Id. at 549.
73. Id. at 555-56; see United States v. Ortiz, 422 U.S. 891, 896-97 (1975) (holding that Fourth Amendment requires probable cause or consent to authorize vehicle searches at permanent border checkpoints); Almeida-Sanchez v. United States, 413 U.S. 266, 272-73 (1973) (holding that roving border patrol stops conducted without any individualized suspicion violated Fourth Amendment and implicitly requiring probable cause for such stops); cf. United States v. Brignon-Ponce, 422 U.S. 873, 880-81 (1975) (holding that roving patrol stops of motorists in border area could be justified by reasonable suspicion).
and private interests at issue, including the potential for creating fear and concern in the motorists being stopped, to determine Fourth Amendment reasonableness.\textsuperscript{74} Thus, in the seizure cases, as well as the search cases, the Supreme Court has concluded that “the Fourth Amendment imposes no irreducible requirement of [individualized] suspicion.”\textsuperscript{75}

The suspicionless search and seizure cases illuminate three considerations that might make non-consensual DNA testing an exception to the general rule of \textit{Schmerber}, requiring a warrant for a blood test.\textsuperscript{76} These considerations include: (1) whether DNA testing represents a minor intrusion comparable to a sobriety checkpoint; (2) whether a state’s interest in establishing a DNA identification database is beyond the ordinary needs of law enforcement or is comparable to the governmental interest in preventing drunk driving or illegal immigration; and (3) whether prisoners have a reduced expectation of privacy comparable to employees in a comprehensively regulated industry.

In \textit{Dunn v. White},\textsuperscript{77} the United States Court of Appeals for the Tenth Circuit looked to both the prisoners’ rights cases\textsuperscript{78} and to the suspicionless search cases\textsuperscript{79} in upholding mandatory, non-consensual AIDS testing of prisoners.\textsuperscript{80} Initially, the court reviewed Supreme Court precedent regarding prisoners’ rights, including \textit{Bell} and \textit{Hudson}, and prison drug testing cases in other circuits.\textsuperscript{81} The court then applied the “special needs” test from \textit{Skinner},\textsuperscript{82} noting that the \textit{Skinner} Court had identi-
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fixed operating a prison as a "special need" of law enforcement.83 The Dunn court then balanced "the intrusiveness of the blood test against the prison's need to administer the test."84 Thus, Dunn provides one model for Fourth Amendment analysis of blood testing in the prison setting.85 Determining whether this model is appropriate for evaluating the constitutionality of non-consensual blood tests to provide samples for DNA testing, however, first requires an understanding of forensic DNA testing itself.

B. Forensic DNA Testing

The reliability and admissibility of the evidence produced by a DNA database necessarily affect the governmental interest in testing prisoners to create that database. If DNA identification evidence were perfectly reliable and universally admissible, then the governmental interest in creating a DNA database from which to obtain this evidence would be very strong. Similarly, the information about the prisoner that DNA test results confer affects the prisoner's privacy interest. A committee of the National Research Council has considered these concerns and has made recommendations regarding the advisability of creating databases of DNA test results for use in later criminal investigations.86 This section will address the reliability,87 admissibility88 and privacy89 issues before going on to consider the committee report.

1. DNA Analysis Techniques

Scientists and courts almost universally accept the general scientific principles that underlie DNA testing (the "DNA paradigm").90 For ex-

83. Dunn, 880 F.2d at 1194 (citing Skinner v. Railway Labor Executives' Ass'n, 498 U.S. 602, 620 (1989)).
84. Id. at 1194.
85. Id. at 1194-97 (holding non-consensual HIV testing of prisoner constitutional using "special needs" test).
86. DNA TECHNOLOGY, supra note 2, at 111-30. For a discussion of the committee's conclusions and recommendations, see infra notes 151-60 and accompanying text.
87. For a discussion of the procedural and statistical sources of error that impact on the reliability of DNA identification evidence, see infra notes 107-20 and accompanying text.
88. For a discussion of the admissibility of DNA identification evidence, see infra notes 122-42 and accompanying text.
89. For a discussion of the information conferred by DNA test results, see infra notes 143-49 and accompanying text.
91. Thompson & Ford, supra note 2, at 60, 61 & n.75 (1989) (recommending both technical, scientific sources and more approachable references on DNA paradigm); see State v. Cauthron, 846 P.2d 502, 511 (Wash. 1993) ("[N]o court has rejected RFLP testing on the basis that it was not generally accepted by the scientific community."); GENETIC WITNESS, supra note 2, at 3-6, 41-50
ample, there is near-universal agreement that the DNA molecule takes the form of a double helix, or twisted ladder, whose rungs are pairs of molecules called bases that combine only in a known way.\textsuperscript{92} The sequence of these base-pairs contains the inherited genetic information that makes the individual unique.\textsuperscript{93} For DNA identification, the principle that DNA is unique to the individual (except an identical twin) and unchanging over his or her life is the most significant aspect of the DNA paradigm.\textsuperscript{94} Even though each person's DNA is unique, "the similarities among individuals of the same species far outnumber the differences."\textsuperscript{95} Only certain sections of the DNA molecule vary among individuals; these sections are known as "polymorphic."\textsuperscript{96} Testing DNA in order to identify the donor, known as DNA "typing" or "fingerprinting" (describing DNA paradigm); Michael J. DiRusso, \textit{DNA "Profiles" — The Problems of Technology Transfer, 8 J. Hum. Rts. 183, 185 n.15 (1990) (citing Caldwell v. Georgia, 393 S.E.2d 436 (1990) (defendant challenged quality control in DNA testing not underlying science)).

Professors Thompson and Ford identify four key tenets of the DNA paradigm. Thompson \& Ford, \textit{supra} note 2, at 60-63. First, DNA is unique to the individual (except an identical twin), but unchanging over the individual's life. \textit{Id.} at 61-62. Second, the structure of the DNA molecule is a double helix, or "twisted ladder," with rails of phosphate and sugar and rungs of pairs of four molecules or "bases" (A, T, G, and C). \textit{Id.} at 62. These bases combine according to the base-pair rule: A with T and C with G. \textit{Id.} Third, the order of the base-pairs along the DNA molecule is called the "DNA sequence" or "genetic code." \textit{Id.} Only certain sections of this code vary among individuals; they are known as "polymorphic." \textit{Id.} Different versions of the same gene (sequence of base pairs) are known as "alleles." \textit{Id.} Fourth, the DNA molecule can be disassembled by either breaking it into shorter fragments or "unzipping" it into two single strands of DNA. \textit{Id.} at 62-63. The combination of two complementary single strands of DNA according to the base-pair rule is called "hybridization." \textit{Id.} at 63. Genetic engineers have created molecules called "genetic probes" that seek out and lock on to complementary sequences during hybridization. \textit{Id.}

92. Thompson \& Ford, \textit{supra} note 2, at 62. The significance of this feature of DNA is that a single strand of DNA will combine, or "hybridize," only with a complementary strand. \textit{Id.} at 63. Thus, "genetic probes," which are single strands of DNA of a known composition, will only combine with complementary strands, conclusively demonstrating the presence of the reciprocal series of bases in the DNA being tested. \textit{Id.}

93. \textit{Id.} at 61 ("DNA is unique but unchanging."); see Kelly et al., \textit{supra} note 90, at 105-06 (referring to chromosomes, which are made up of DNA, as "human blueprint").

94. Thompson \& Ford, \textit{supra} note 2, at 61-62; see DNA TECHNOLOGY, \textit{supra} note 2 at 9 ("[N]o two persons (barring identical twins) have the same DNA sequence.").

95. Thompson \& Ford, \textit{supra} note 2, at 63.

96. \textit{Id.} at 62; see State v. Cauthron, 846 P.2d 502, 513 (Wash. 1993) (noting that "only a small percentage of the overall number of positions on the human genome [total DNA sequence] are variable (0.1 to 0.3 percent of 3 billion [positions])" (citation omitted)). Different versions of the same gene (sequence of base pairs) are known as alleles. Thompson \& Ford, \textit{supra} note 2, at 62. Testing a sample for the presence or absence of certain alleles is an alternative to RFLP as a method of DNA analysis. \textit{Id.} at 64, 76-81 (discussing allele specific probe analysis as provided by Cetus Corporation).
The technique most commonly used for DNA identification is restriction fragment length polymorphism (RFLP) analysis.\(^{98}\) RFLP analysis is used by the FBI and is one of three commercially available methods of DNA identification.\(^{99}\) RFLP analysis consists of a series of seven separate procedures.\(^{100}\) DNA testing technology does not presently allow.

97. See Cauthron, 846 P.2d at 513; Thompson & Ford, supra note 2, at 63 (“The particular breakthrough that allowed DNA to be ‘typed’ was the development of genetic probes capable of identifying polymorphic DNA segments, those small areas within the DNA chain where the differences among individuals are most pronounced.”) (footnote omitted). The Cauthron court stated:

If the autorad [produced by RFLP analysis] reflects only monomorphic sites, it imparts no information whatsoever about the defendant. In other words, if the probes used only detect sites on the DNA which are common to all human beings, the evidence obtained cannot be the basis for identifying the defendant.

Cauthron, 846 P.2d at 513.

98. Genetic Witness, supra note 2, at 4 (“Although the specific protocols used for RFLP analysis vary from laboratory to laboratory, the vast majority of forensic casework carried out today involves this basic approach.”); see Thompson & Ford, supra note 2, at 48 (noting that RFLP analysis is probably best known).

99. Thompson & Ford, supra note 2, at 48-49. These three tests are: “DNA fingerprinting,” offered by Cellmark Diagnostics Corporation, “DNAPrint,” offered by Lifecodes Corporation, and the test offered by the Cetus Corporation. Id. Both “DNAPrint and “DNA fingerprinting” use RFLP analysis. Id. For a discussion of the relative merits of the three tests, see Thompson & Ford, supra note 2, at 48-52; and DiRusso, supra note 91, at 189-191 (comparing RFLP analysis and Cetus test). For a list of major articles regarding each test, see Thompson & Ford, supra note 2, at 59 n.70. For a lengthy discussion of the Cellmark test and its treatment by the courts, see Colorado v. Lindsey, No. 90-CA0556, 1993 WL 2650, at *5-7 (Colo. Ct. App. Jan. 7, 1993) (affirming trial court’s admission of DNA testing evidence performed by Cellmark).

This Note, however, addresses only the method of DNA testing at issue in Jones v. Murray; the “DNAPrint” test, which uses the RFLP analysis testing method. See Jones v. Murray, 962 F.2d 302, 304 (4th Cir.) (identifying and describing the “DNAPrint” test), cert. denied, 113 S. Ct. 472 (1992); Thompson & Ford, supra note 2, at 48 (identifying “DNAPrint test” as product of RFLP analysis). The “DNAPrint” test used in Virginia is the result of RFLP analysis and is ordinarily a product of Lifecodes Corporation. Thompson & Ford, supra note 2, at 48-49. However, Virginia was the first state to conduct its own DNA testing. Genetic Witness, supra note 2, at 151 Box 6-D. Virginia entered into a technology transfer program with Lifecodes Corporation whereby “selected Virginia laboratory personnel received [four] weeks of training at the Lifecodes facility in New York to learn DNA typing procedures and quality control measures, and take a proficiency test.” Id. Although Virginia uses the FBI protocol, it is still based on RFLP analysis. Id. at 116, 151 Box 6-D.

100. Thompson & Ford, supra note 2, at 64-76; see Genetic Witness, supra note 2, at 44-46 (six steps, not including interpretation); DiRusso, supra note 91, at 197-99 (relying partly on Thompson and Ford). For a more scientifically sophisticated discussion of RFLP analysis, see DNA TECHNOLOGY, supra note 2, at 36-40.
direct examination of the total unique sequence of base-pairs along the DNA molecule.\textsuperscript{101} Instead, RFLP analysis examines the length of the fragments on which certain polymorphic base-pair sequences appear when the DNA molecule is cut in predetermined places.\textsuperscript{102} RFLP analysis thereby produces an autoradiograph with dark bands; these bands indicate the presence of fragments containing the sought-after sequences and the approximate length of those fragments.\textsuperscript{103}

The basic premise of DNA identification through RFLP analysis has been described thus:

In samples from a given individual, the fragments identified by

First, the DNA is extracted from the biological material (i.e. blood) that may have dried onto a surface such as clothing. Thompson \& Ford, supra note 2, at 65-67. Next, the DNA molecule is “cut” at specific sites in a process called restriction digestion. \textit{Id.} at 67-69. The third step is gel electrophoresis, where electrical current is used to sort the negatively charged fragments by length. \textit{Id.} at 69-70. Fourth, a “permanent ‘copy’” of the array of DNA fragments is transferred onto a sheet of nylon membrane, by a process called Southern transfer, and the fragments are separated into single strands. \textit{Id.} at 70-71. The fifth step is hybridization, where the radioactively tagged probe molecule locks onto a specific polymorphic DNA segment on the blot. \textit{Id.} at 71-74. Sixth, the blot is placed on a piece of X-ray film; the radioactive tagged probe molecule exposes the film at the location of the polymorphic DNA segment. \textit{Id.} at 74. Finally, technicians interpret the resulting autoradiographs to determine whether the bands produced by the unknown sample match those produced by the known sample. \textit{Id.} at 74-76.

101. \textit{Genetic Witness, supra} note 2, at 42 (stating that DNA testing provides “snapshot of a specific area” on DNA molecule); \textit{see DNA Technology, supra} note 2, at 28 (“Thus, the traditional forensic paradigm of genetic testing as a tool for exclusion was in a linguistic stroke [fueled by mass media accounts of DNA testing] changed to a paradigm of identification.”). DNA profiling actually tests “identifiable length polymorphisms,” places where given fragments of DNA vary in length from individual to individual. DiRusso, \textit{supra} note 91, at 189 (“[T]hese identifiable length polymorphisms . . . are the subject of the rest of the DNA testing and analysis.”).

102. DiRusso, \textit{supra} note 91, at 188-89 (“These tests essentially measure the resulting polymorphic fragments to see if they match.”). These fragments are produced by “restriction enzymes”: naturally occurring compounds that recognize certain palindromic base-pair sequences and break the DNA molecule only in those places. Kelly et al., \textit{supra} note 90, at 107. Different individuals’ DNA will contain these palindromic base-pair sequences at different locations on the DNA molecule, thus creating fragments of different lengths; this variation in the length of the fragments produced is “length polymorphism.” DiRusso, \textit{supra} note 91, at 188-89. Because a given length fragment may be found in a significant proportion of the population, DNA tests examine several different fragments. Thompson \& Ford, \textit{supra} note 2, at 48 (“likelihood of a coincidental match on all of the bands [produced by different fragments] is low”); \textit{see Richard Lempert, Some Caveats Concerning DNA as Criminal Identification Evidence: With Thanks to the Reverend Boys, 13 CARDozo L. REV. 303, 314 (1991) (noting that at present three to four sites are tested and suggesting that greater reliability would be achieved if more sites were tested).

103. Kelly et al., \textit{supra} note 90, at 108 (comparing pattern of bands produced on autoradiograph to “bar code on the side of a food package”); \textit{see Longobardi, supra} note 3, at 929 (reproducing with permission photograph of example of DNA identification autoradiograph produced by RFLP).
the probe will be the same length, while in samples from different individuals the length of these fragments is likely to differ. Hence, if the probe identifies fragments of the same length in two samples, it is evidence that the samples have a common source.¹⁰⁴

This information is merely evidence of a common DNA source because although generally no two people have identical DNA, two people can nonetheless have identical DNA test results, or DNA profiles.¹⁰⁵ The results are the same because DNA testing compares only a very small minority of the millions of places in which two people’s DNA may differ.¹⁰⁶ Once a suspect’s DNA and crime scene evidence containing DNA have been tested, and the results have been compared, the reliability and admissibility of this information as evidence remains to be determined.

2. Reliability of DNA Identification Evidence

Commentators have recently raised caveats concerning the reliability of DNA identification evidence.¹⁰⁷ Their concerns focus on two is-

¹⁰⁴. Thompson & Ford, supra note 2, at 64. “Because the polymorphic [DNA] segments differ markedly from one individual to the next, the length of the restriction fragments containing these key DNA segments is likely to differ among individuals as well.” Id. at 67-68. Another commentator has summarized the process somewhat differently:

Stated simply, DNA identification testing takes advantage of these variations in RFLP length by extracting DNA from a tissue sample, cutting the DNA into its characteristic lengths, separating those lengths on the basis of size and visualizing the separated fragments on photographic film by means of radioactive probes. If performed properly, this process yields an RFLP banding pattern, or autoradiograph, that is highly characteristic of the individual and which may be useful for matching forensic samples to a suspect....


¹⁰⁵. Thompson & Ford, supra note 2, at 80 ("[T]wo unrelated individuals may be identical with regard to the polymorphism examined by a particular test, and therefore can have the same DNA type."); id. at 80 n.163 (noting greater probability of coincidental match between two related individuals); DNA Technology, supra note 2, at 9 (noting chance of same results from different individuals due to small number of sites tested and "limited resolution for measuring the variability at each site"); see DiRusso, supra note 91, at 187 (calling this fact "crux" of controversy regarding transfer of DNA analysis technology from laboratory to courtroom); cf. State v. Cauthron, 846 P.2d 502, 512 (Wash. 1993) ("There is no doubt that if the technology existed to analyze the entire length of DNA and compare it to another complete DNA molecule, an absolute identification could be provided.").

¹⁰⁶. DNA Technology, supra note 2, at 74. The authors of DNA Technology suggest that despite the chance that two people’s DNA test results might be identical, a "match" between two test results should nonetheless "be considered strong evidence that the two samples came from the same source." Id.

¹⁰⁷. See, e.g., Lempert, supra note 102, at 334-35 (noting that DNA testing technology is "in its infancy"); DNA Technology supra note 2, at 1 ("important
issues: the proficiency of DNA testing laboratories and the statistical assumptions underlying the manner in which experts present DNA identification evidence to a jury. Procedural problems affect the reliability of DNA identification evidence because DNA analysis is an exacting scientific process “where nuances of laboratory procedure can have a dramatic effect on the reliability of the test.” In addition, because DNA testing procedures were originally developed for use on pristine laboratory samples, the age and condition of samples obtained from crime scenes have been raised about reliability, validity, and confidentiality” of DNA typing; see also Thompson & Ford, supra note 2, at 48 (intent of article was to “identify and illuminate the key issues that are likely to arise with regard to the reliability of DNA typing evidence”).

108. For a discussion of the procedural sources of error in forensic DNA testing, see infra notes 109-12 and accompanying text. For a discussion of the statistical sources of error, see infra notes 113-20 and accompanying text.

109. Thompson & Ford, supra note 2, at 58; see State v. Bruno, 424 S.E.2d 440, 445 (N.C. Ct. App. 1993) (“[A] trial court may decide as a matter of law that DNA evidence is inadmissible for any number of reasons including, but not limited to, unreliable procedures or results, contamination of the sample or chain of custody questions.”); People v. Castro, 545 N.Y.S.2d 985, 996, 999 (N.Y. Sup. Ct. 1989) (excluding DNA identification evidence as being result of faulty laboratory procedures); see also Thompson & Ford, supra note 2, at 52, 64 (noting that DNA analysis requires “complicated series of procedures, drawn from molecular biology, which may vary in their reliability and degree of acceptance in the scientific community” and that “[u]nreliability in any one of these procedures can compromise the over-all validity of the test”); Boyce Rensberger, New Way is Developed to Improve DNA Tests, The Houston Chron., Aug. 18, 1992, at A3 (“[B]ecause the test’s reliability depends on how carefully a laboratory performs the procedure, false results can be more common.”). For a discussion of the error potential of each step of RFLP analysis, with special attention to potential errors in the forensic setting, see Thompson and Ford, supra note 2, at 64-76.

An example of a court addressing the complexity of the RFLP analysis procedures and the effect that laboratory conditions and scientific assumptions can have on test results is People v. Keene, 591 N.Y.S.2d 733 (Sup. Ct. 1992). The Keene court was asked to determine the admissibility of DNA identification evidence that was challenged on the basis of an occurrence of “band-shift” on the autoradiographs and the procedures the commercial testing laboratory had used to correct for the problem. Id. at 736. “Band-shift” is the phenomenon of the bands on the autoradiograph in the suspect and evidence “lanes” lining up similarly in a given area of the gel, but consistently not in the same place. Id. at 737; see Thompson & Ford, supra note 2, at 70 (discussing possibility of “band-shift”). This phenomenon may be caused by differences in the amount of sample on the gel, the salinity of the gel or other environmental factors. Keene, 591 N.Y.S.2d at 738; DNA TECHNOLOGY, supra note 2, at 60. The Keene court held that the commercial laboratory’s method of correcting for “band-shift,” the use of monomorphic probes, which ought to appear in the same place in both samples, did not meet the Frye “general acceptance” test; consequently, the court ruled the DNA identification evidence inadmissible. Keene, 591 N.Y.S.2d at 740-41. In reaching its conclusion, the Keene court relied in part on the analysis of the “band-shift” problem and the use of monomorphic probes to correct for it found in DNA TECHNOLOGY, supra note 2, at 60-61, quoted in Keene, 591 N.Y.S.2d at 740.
scenes can also create procedural error. This consideration is particularly important because samples found at crime scenes are frequently degraded. Commentators have suggested various methods to correct these sources of procedural error, such as periodic testing of laboratories and the development of strict quality control standards.

In addition to error resulting from problems in testing procedures, the statistical problems inherent in DNA testing are a second and more complicated source of unreliability. Because DNA test results are not unique to the individual, their value as evidence must be expressed in

110. Thompson & Ford, supra note 2, at 65-66. First, the DNA in the sample may have begun to age and break down into shorter fragments. Id. at 65 & n.89. If the analyst fails to recognize that the sample is degraded or that there is insufficient material for reliable analysis, error will result. Id. at 65-66. Second, the sample may be contaminated with "other chemical or biological agent[s] which could interfere with the reliability of subsequent procedures." Id. at 66. Such chemical agents are present in carpet cleaning fluids, detergents and dry-cleaning fluids and could easily contaminate an evidence sample. Id.

111. See DNA TECHNOLOGY, supra note 2, at 6 (stating that forensic DNA analysis often involves "samples that are degraded, contaminated, or from multiple unknown sources"); DiRusso, supra note 91, at 201 (citing Memorandum in Opposition to the Introduction of DNA Evidence at 38; People v. Castro, 545 N.Y.S.2d 985 (N.Y. Sup. Ct. 1989)); see also Thompson v. State, 615 So. 2d 737, 740 (Fla. Dist. Ct. App. 1993) (explaining that forensic pathologist testified that FBI lab considered five-year-old evidence containing semen stains too old for DNA testing). But see People v. Wesley, 589 N.Y.S.2d 197, 200 (App. Div. 1992), aff'd, No. 18, 1994 WL 95513 (N.Y. Mar. 29, 1994). In Wesley, the court noted that:

While RFLP testing in the forensic arena presents unique problems not encountered in other areas because the samples from which the DNA is extracted often are contaminated or exposed to environmental influences, expert testimony [in the lower court] also established that these factors do not degrade the quality of the DNA or compromise the fingerprint.

Id.

112. See Thompson & Ford, supra note 2, at 66-67 (advocating independent validation studies of testing laboratories to determine reliability of their tests when faced with variously degraded samples). Similarly, a panel of the National Research Council of the National Academy of Sciences has endorsed forensic DNA analysis in principle, but urged development of better quality control methods. DNA TECHNOLOGY, supra note 2, at 8, 51-73 (introduction and chapter concerning recommendations for DNA testing procedure); see Boyce Rensberger, New Way is Developed to Improve DNA Tests, The Houston Chron., Aug. 18, 1992, at A3. One quality control method is to include in each test a set of DNA samples from laboratory-grown human cells with a known DNA profile. Id. Any variation in the test results of the known sample will be apparent to the technicians performing the test, revealing the effect of any procedural error. Id.

113. See Lempert, supra note 102, at 305-12 (identifying procedural and statistical problems including effect of sub- and micropopulations and limitations of frequentist statistics); see also DNA TECHNOLOGY, supra note 2, at 75 (describing recent Maryland murder case where estimates of DNA pattern frequency ranged from 1 in 500 to 1 in 739 billion, depending on underlying statistical assumptions). For a sophisticated and comprehensive scientific discussion of the population genetics principles underlying DNA analysis, see DNA TECHNOLOGY, supra note 2, at 44-50, 74-96.
terms of the probability that someone other than the suspect left the
evidence sample at the crime scene.\textsuperscript{114} The likelihood of a coincidental
match is calculated by finding the probability associated with each of the
polymorphisms that appear, then calculating the probability of the
whole series of polymorphisms, the DNA profile, appearing together.\textsuperscript{115}
The potential for statistical error arises because the formula used to cal-
culate the frequency of the DNA profile in the population is "only valid
when applied to populations in which the DNA fragments are statisti-
cally independent."\textsuperscript{116} The polymorphisms are statistically independ-

\begin{itemize}
  \item 114. See DNA Technology, supra note 2, at 9 ("To say that two patterns
match, without providing any scientifically valid estimate (or, at least, an upper
bound) of the frequency with which such matches might occur by chance, is
meaningless."). Forensic DNA testing involves application of population genetics in order to "approximate the degree to which two samples are associated by
greater than random chance." Genetic Witness, supra note 2, at 6; see DNA
Technology, supra note 2, at 4 (stating that once two DNA test patterns match,
question becomes: "What is the probability that such a match would have occurred
between the suspect and a person drawn at random from the same population
as the suspect?"); see also id. at 124 (noting important distinction between
finding a match between suspect and evidence samples and finding match be-
tween suspect and database samples because chances of match with database are
much greater).

Finding that two specimens produce the same DNA pattern is analogous to
finding that two specimens are the same blood type. Genetic Witness, supra
note 2, at 66. In neither case does the test result mean that the specimens were
necessarily left by the same individual. Id. Population genetics provides the
"numerical weight" to be placed on the match—the chance that it could have arisen randomly. Id. For example, in one recent case, the prosecution at-
ttempted to introduce DNA evidence to identify the suspect, claiming before the
trial judge that the probability of a coincidental match was one in 40,000,000
and arguing before the District of Columbia Court of Appeals that a probability
of one in 270,000 should be presented to the jury. United States v. Porter, 618

115. Genetic Witness, supra note 2, at 66 (noting that population frequency
of DNA pattern is calculated by "ascertaining the frequency of individual
bands . . . . [and] estimating the population frequency of the overall DNA pat-
tern"); DiRusso, supra note 91, at 210 ("Essentially, all that needs to be done is
to take the bands on the [autoradiograph], determine their uniqueness in the
population and then make a calculation of the odds that the specific combination
of unique bands would occur in the population."); DNA Technology, supra
note 2, at 10 ("Each matching allele is assumed to provide statistically independent
evidence, and the frequencies of the individual alleles are multiplied to-
gether to calculate a frequency of the complete DNA pattern.").

Merely calculating the frequency of a given polymorphism in the population
may create its own error potential, however, where the population studies used
in this calculation are inadequate. Thompson & Ford, supra note 2, at 84 &
n.177 (noting error potential created by population studies published, and re-
lied upon, by Lifecodes Corporation that were conducted on "relatively small,
nonrandom samples"); see Colorado v. Lindsey, No. 90-CA0556, 1993 WL
2650, at *1 (Colo. Ct. App. Jan. 7, 1993) (noting that database used "ultimately comprised DNA samples from blood taken from approximately 390 black do-
nors at a Detroit blood bank").

116. Genetic Witness, supra note 2, at 67; see Thompson & Ford, supra
note 2, at 82 (calculation invalid if probability of finding one polymorphism is
ent only if the probability that a particular polymorphism will be found is unaffected by the probability that another will be found.117 If the variations are not in fact independent, assuming that they are "could allow misleading statistical testimony which greatly underestimates the probability of a coincidental match," thus greatly overestimating the likelihood that the evidence was left by the defendant.118 Restated, if the probability of finding one fragment is affected by the probability of finding another, there is a danger of substantially underestimating the likelihood of a coincidental match.119 Recently, the Supreme Court of Washington acknowledged these considerations in reversing a rape conviction based in part on DNA identification evidence.120 The effect of

affected by presence of another); DNA TECHNOLOGY, supra note 2, at 10 ("scientific validity" of calculation depends on whether matches of each polymorphism "are actually statistically independent").

117. Thompson & Ford, supra note 2, at 81 ("The bands [representing particular polymorphisms] are said to be independent if the probability of a match on each band is unaffected by the occurrence of a match on any other band."); GENETIC WITNESS, supra note 2, at 67 ("Essentially, the population must be one where individuals randomly marry and reproduce, so that distinct subgroups are absent."); see Commonwealth v. Curnin, 565 N.E.2d 440, 445 (Mass. 1991) (holding DNA evidence improperly admitted because based on statistical assumptions that were neither generally accepted nor inherently rational); Caldwell v. State, 393 S.E.2d 436, 443-44 (Ga. 1990) (reducing statistical weight of DNA evidence to size of database rather than allowing commercial laboratory's "enormous claimed power of identity").


119. GENETIC WITNESS, supra note 2, at 67 ("[T]he value calculated might greatly underestimate the true occurrence pattern in the general population—making a match seem rarer than it actually is.").

120. State v. Cauthron, 846 P.2d 502, 512-18 (Wash. 1993). In Cauthron, the Supreme Court of Washington found "significant disagreement within the scientific community regarding the validity of the databases used to construct the probability estimates which ultimately determine identity." Id. at 505. The court concluded that the trial court had admitted the evidence of a DNA "match" in error because it was "not accompanied by statistical verification." Id.
these concerns regarding the reliability of DNA analysis for identification on the admissibility of the results as evidence varies from court to court.\textsuperscript{121}

3. Admissibility of DNA Identification Evidence

Although courts have admitted DNA evidence for identification purposes in criminal trials and paternity suits since 1988,\textsuperscript{122} the appropriate standard for its admissibility has proven to be a difficult issue for the courts.\textsuperscript{123} Among state courts, there are three major approaches: the traditional, \textit{Frye} "general acceptance" test,\textsuperscript{124} the "relevancy" test,\textsuperscript{125} and a three-pronged test enunciated by the court in \textit{People v. Cas-}

The court reversed the defendant’s conviction on seven counts of first degree rape, but remanded “for reconsideration of the statistical evidence in light of current scientific knowledge.” \textit{Id.}; see United States \textit{v.} Porter, 618 A.2d 629 (D.C. 1992) (majority and dissent differing over admissibility of DNA identification evidence based upon scientific disagreement regarding statistics used).

\textsuperscript{121} See, \textit{e.g.}, \textit{People v. Wesley}, 589 N.Y.S.2d 197, 199, 201 (N.Y. App. Div. 1992) (suggesting that under "general acceptance" test, "ancillary issues regarding the integrity of the particular forensic sample . . . and whether the laboratory followed the accepted procedures in carrying out the tests . . . speak to the weight the evidence is accorded" and concluding that statistical assumptions used by commercial laboratory met "general acceptance" requirement), \textit{aff’d}, No. 18, 1994 WL 99513 (N.Y. Mar. 29, 1994). For a discussion of the various standards applied by courts in determining whether DNA evidence is admissible, see \textit{infra} notes 122-42 and accompanying text.


\textsuperscript{123} See United States \textit{v. Martinez}, 3 F.3d 1191, 1195 & n.7 (8th Cir. 1993) (noting that “[t]here is no consensus among the state courts which have considered the admissibility of DNA evidence”). Numerous student-written commentaries have been published comparing the standards adopted in different jurisdictions. See, \textit{e.g.}, Elizabeth M. Bezak, \textit{Note, DNA Profiling Evidence: The Need for a Uniform and Workable Evidentiary Standard of Admissibility}, 26 V. L. REV. 595 (1992); Daniel C. Burke & Brian J. Whiteman, \textit{Note, Argue with Science? The Admissibility Debate Surrounding DNA Identification}, 7 ST. JOHN’S J. LEGAL COMMENT. 597 (1992).

\textsuperscript{124} See, \textit{e.g.}, \textit{State v. Cauthron}, 846 P.2d 502, 505 & n.2 (Wash. 1993).

\textsuperscript{125} See, \textit{e.g.}, \textit{Prater v. State}, 820 S.W.2d 429, 431 (Ark. 1991) (adopting relevancy test). According to the \textit{Prater} court, the "relevancy" approach is based upon the Uniform Rules of Evidence and requires a three-fold analysis by the court before testimony advancing novel scientific evidence will be admitted. \textit{Id.} The court must inquire into “(1) the reliability of the novel process used to generate the evidence, (2) the possibility that admitting the evidence would overwhelm, confuse or mislead the jury, and (3) the connection between the novel process evidence to be offered and the disputed factual issues in the particular case.” \textit{Id.}
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The "general acceptance" test for the admissibility of novel scientific evidence was first announced in *Frye v. United States.* The *Frye* test, novel scientific evidence may only be admitted if its proponent can establish that it is based on scientific principles that have gained "general acceptance" within the relevant scientific community. Under the relevancy test, the court admits scientific evidence whenever its proponent can demonstrate that it is reliable, will not confuse or mislead the jury and is related to the facts at issue. The *Castro* court created its test specifically to consider the admissibility of forensic DNA evidence. Under the *Castro* test, forensic DNA evidence is admissible if its proponent can demonstrate that the theory underlying it is generally accepted in the scientific community, that DNA testing can produce reliable results and that the DNA testing procedures were correctly performed in producing the evidence sought to be admitted.

After it was announced in 1923, a majority of jurisdictions adopted the *Frye* test. By 1991, however, approximately one third of jurisdic-

126. People v. Castro, 545 N.Y.S.2d 985, 987-88 (Sup. Ct. 1989). The *Castro* test, which is an extension of the *Frye* test, asks three questions:

*Prong I.* Is there a theory, which is generally accepted in the scientific community, which supports the conclusion that DNA forensic testing can produce reliable results?

*Prong II.* Are there techniques or experiments that currently exist which are capable of producing reliable results in DNA identification and which are generally accepted in the scientific community?

*Prong III.* Did the testing laboratory perform the accepted scientific techniques in analyzing the forensic samples in this particular case?

Id. at 987.

127. *Frye v. United States,* 293 F. 1013 (D.C. Cir. 1923). The *Frye* court stated:

Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs.

Id. at 1014.


129. Prater v. State, 820 S.W.2d 429, 431 (Ark. 1991). The *Prater* court considered reliability to be the "critical element" of the relevancy test. Id.


131. Daubert v. Merrell Dow Pharmaceuticals, Inc., 113 S. Ct. 2786, 2792 (1993) ("In the 70 years since its formulation in the *Frye* case, the "general acceptance" test has been the dominant standard for determining the admissibility of novel scientific evidence at trial."); United States v. Martinez, 3 F.3d 1191, 1195 (8th Cir. 1993); Prater v. State, 820 S.W.2d 429, 431 (Ark. 1991); Thompson & Ford, *supra* note 2, at 55; DNA TECHNOLOGY, *supra* note 2, at 132 (stating that *Frye* test "has been the most frequently invoked one in American case law").
tions had rejected Frye and adopted the "relevancy" approach.\textsuperscript{132} Recently, a few states have applied the stricter Castro test in considering the admissibility of DNA identification evidence.\textsuperscript{133}

In the federal system, the Supreme Court recently clarified the issue of the applicable test for the admissibility of scientific testimony in \textit{Daubert v. Merrell Dow Pharmaceuticals, Inc.}\textsuperscript{134} In \textit{Daubert}, the Court held that the Federal Rules of Evidence supersede the Frye rule.\textsuperscript{135} The Court suggested that Federal Rule of Evidence 702 necessitated a two-pronged inquiry into "whether the reasoning or methodology underlying the testimony is scientifically valid and of whether that reasoning or methodology properly can be applied to the facts in issue."\textsuperscript{136} The only United States Court of Appeals to rule on the admissibility of DNA identification evidence since \textit{Daubert} was the United States Court of Appeals for the Eighth Circuit in \textit{United States v. Martinez}.\textsuperscript{137} In \textit{Martinez}, the

\textsuperscript{132} Prater v. State, 820 S.W.2d 429, 431 (Ark. 1991).


\textsuperscript{135} Id. at 2793-94.

\textsuperscript{136} Id. at 2796. Federal Rule of Evidence 702 provides: "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise." Fed. R. Evid. 702. The \textit{Daubert} Court interpreted Rule 702 to require the offered evidence to meet "a standard of evidentiary reliability" that, in the case of scientific evidence, is based upon "scientific validity." \textit{Daubert}, 113 S. Ct. at 2795 & n.9. The Court further held that Rule 702 "requires a valid scientific connection to the pertinent inquiry as a precondition to admissibility." Id. at 2796.

\textsuperscript{137} United States v. Martinez, 3 F.3d 1191 (8th Cir. 1993). Prior to the Supreme Court's decision in \textit{Daubert}, two United States Courts of Appeals had ruled on the admissibility of DNA identification evidence, and each had applied a different test. \textit{Compare} United States v. Jakobetz, 955 F.2d 786, 794, 797-800 (2d Cir.), cert. denied, 113 S. Ct. 104 (1992) \textit{with} United States v. Two Bulls, 918 F.2d 56 (8th Cir.) (original panel decision was vacated and permission for rehearing en banc granted; case was dismissed as moot when defendant died), dismissed, 925 F.2d 56 (8th Cir. 1990).

The United States Court of Appeals for the Second Circuit based its \textit{Jakobetz} decision on a balancing test for the admissibility of novel scientific evidence which it had announced in United States v. Williams, 583 F.2d 1194 (2d Cir. 1978), cert. denied, 439 U.S. 1117 (1979). \textit{Jakobetz}, 955 F.2d at 794, 797-800. In \textit{Williams}, the court admitted voice spectrographic evidence after balancing its probative value, materiality and reliability against its tendency to mislead the jury. 583 F.2d at 1198-1200. In \textit{Jakobetz}, the Second Circuit declined to depart from the \textit{Williams} balancing approach in determining the admissibility of DNA evidence and "balance[ed] . . . the reliability of the evidence against its potential negative impact on the jury." \textit{Jakobetz}, 955 F.2d at 794, 797-800.
Eighth Circuit held that DNA identification evidence was admissible under the Supreme Court's Daubert analysis.\footnote{138} The court held that the lower court had not abused its discretion in admitting the evidence after conducting a hearing in which it applied the Castro test.\footnote{139} Before reaching its holding, the Martinez court broadly discussed the Daubert Court's approach to the admissibility of evidence under Rule 702 and characterized it as a flexible inquiry into reliability.\footnote{140} The Martinez court then took judicial notice of the Second Circuit's conclusions regarding the reliability of the general theory and techniques of DNA testing and concluded that they were valid under the Daubert admissibility analysis, but cautioned that such notice did not make DNA identification evidence

In contrast, a panel opinion from the United States Court of Appeals for the Eighth Circuit suggested that "[b]ecause DNA evidence is so new and the resulting prejudice to the defendant is sufficiently great," a stricter, three-prong test should be used. Two Bulls, 981 F.2d at 60. In Two Bulls, the court described the applicable test: "(1) whether the DNA evidence is scientifically acceptable, (2) whether there are certain standard procedures that should be followed in conducting these tests, and (3) whether these standards were followed in this case." \textit{Id.} at 61. This three-prong analysis is similar to the Castro test. See People v. Castro, 545 N.Y.S.2d 985, 987-88 (Sup. Ct. 1989). The Two Bulls court further expanded this inquiry in its instructions to the lower court on remand:

The trial court is to decide (1) whether DNA evidence is generally accepted by the scientific community, (2) whether the testing procedures used in this case are generally accepted as reliable if performed properly, (3) whether the test was performed properly in this case, (4) whether the evidence is more prejudicial than probative in this case, and (5) whether the statistics used to determine the probability of someone else having the same genetic characteristics is more probative than prejudicial under Rule 403.

\textit{Two Bulls}, 981 F.2d at 61.\footnote{138} \textit{Martinez}, 3 F.3d at 1198. The Martinez court identified four factors which the Daubert Court had suggested courts consider in determining the reliability of novel scientific evidence:

1. Whether the scientific technique can be (and has been) tested.
2. Whether the technique or theory has been subjected to peer review and publication. While not a \textit{ sine qua non } of admissibility, "[t]he fact of publication (or lack thereof) in a peer-reviewed journal thus will be a relevant, though not dispositive, consideration in assessing the scientific validity of a particular technique or methodology on which an opinion is premised."
3. The known rate of error of the technique and the existence and maintenance of standards controlling the technique's operation.
4. Whether the technique is generally accepted.
\textit{Id.} at 1196-97 (citing Daubert v. Merrell Dow Pharmaceuticals, Inc., 113 S. Ct. 2786, 2796 (1993)).

139. \textit{Id.} at 1198. The Martinez court noted that the Castro inquiry was "at least as stringent" as the inquiry mandated by the Supreme Court in Daubert. \textit{Id.} The Martinez court further held that under the doctrine of invited error, the defendant was barred from arguing that he was prejudiced by the trial court's exclusion of the expert's estimate of the probability of a coincidental match (1 in 2600) as more prejudicial than probative. \textit{Id.} at 1199.

140. \textit{Id.} at 1197.
automatically admissible. Noting that courts before Daubert had required additional inquiry into whether the expert had properly performed the DNA analysis techniques, the Martinez court concluded that the Daubert reliability inquiry mandated "a preliminary showing that the expert properly performed a reliable methodology in arriving at his [or her] opinion." This controversy, regarding the appropriate inquiry for a court faced with deciding whether to admit DNA identification evidence, shows little sign of abating.

In a Fourth Amendment context, concerns regarding the reliability and admissibility of DNA test results necessarily affect the strength of the governmental interest in obtaining them. Similarly, the information the DNA test results confer about the subject affects the privacy interests of the persons being tested.

4. Privacy Concerns: The Information Conferred

Advocates of DNA identification evidence often dismiss its potential infringement on personal privacy as insignificant. These commentators argue that present methods of DNA testing "yield[] no invasive, substantive information." At present this is true; however, once scientists fully map human DNA, testing for the presence of genes indicating a predisposition towards crime, drug addiction or genetic disease might also be undertaken. If future refinements in DNA testing

141. Id. Further, the court held that as a result, courts could take judicial notice of the reliability of DNA identification theory and techniques in the future. Id. (cautioning, however, that should new DNA analysis techniques be offered into evidence, future courts would be required to hold admissibility hearings under Daubert standard).

142. Id. at 1197-98.

143. See, e.g., Longobardi, supra note 3, at 331-32, 353. Ms. Longobardi argues that DNA test results, "DNA prints," contain no substantive information about the subject. Id. at 331-32 (quoting Tyler Marshall, Scientific Technique Focusing on DNA Aids British Police: 'Genetic Fingerprints' May Catch Killer, L.A. Times, Mar. 11, 1987, part 1 at 1, and noting that subject's sex, race and even species are indeterminable from DNA print). She further contends that because DNA analysis tests only for specific polymorphisms, it would be possible to create a standardized DNA test that tested only for "benign" genetic sequences, those that communicate no sensitive information about the subject. Id. at 353.

144. Id. at 338-39. Ms. Longobardi also points out that present DNA test results indicate only "presence and length of certain highly variable and specialized nucleotide sequences." Id. at 342.

145. Mark A. Rothstein, Foreword to Symposium: Legal and Ethical Issues Raised by the Human Genome Project, 29 Hous. L. Rev. 1, 1 (1992) ("In 1990 the United States officially began the Human Genome Project, a fifteen-year scientific program to map and sequence all of the estimated 50,000 to 100,000 genes within each human being.").

146. See Thompson & Ford, supra note 2, at 50-51 (suggesting that future DNA testing procedures, specifically "DNA sequencing," will provide "a direct readout of the genetic code of DNA" and may become available for courtroom use relatively soon); see also Rothstein, supra note 145, at 2 (suggesting that gene-by-gene readout will be cheaply commercially available in thirty years
produce a gene-by-gene account of an individual's DNA, including those
genes that indicate race, appearance and predisposition to disease, an
individual's privacy interest in that information will accordingly in-
crease.\textsuperscript{147} Even with the present technology, however, the donor has an
interest in the content of the DNA analysis because DNA test results
provide evidence of identity.\textsuperscript{148} Moreover, even present day genetic
identity testing represents a greater intrusion into personal privacy than
do the alcohol and drug-use testing at issue in the Supreme Court cases
creating and applying the "special needs" test.\textsuperscript{149}

5. DNA Databases

In its report entitled DNA Technology in Forensic Science,\textsuperscript{150} a commit-
tee of the National Research Council of the National Academy of Sci-
ences discussed the possibility of the creation of a database or databases

\hspace{1cm} (quoting ROBERT SHAPIRO, THE HUMAN BLUEPRINT 271 (1991)). But see Burk,
supra note 104, at 93 (asserting that DNA sequencing of major portions of sus-
pect's genome, not merely those used for DNA identification, "might constitute
a very real threat to genetic privacy, but is very unlikely to occur" because "[n]o
law enforcement agency is likely to commit" resources necessary).

147. DNA Technology, supra note 2, at 113. The authors of DNA TECH-
NOLOGY observe: "DNA typing can, in principle, also provide personal informa-
tion [in addition to identity]—concerning medical characteristics, physical traits,
and relatedness—that carries with it risks of discrimination. Consequently, DNA
typing raises considerably greater issues of privacy than does ordinary finger-
printing." Id. But see Burk, supra note 104, at 90 ("As a general rule, the pattern
[produced by DNA analysis] will not be useful for purposes besides identifica-
tion. In this respect, it is very much like the fingerprint patterns or photographic
images of criminals now kept by law enforcement agencies." (citation omitted)).
Mr. Burk extensively analyzed the various threats to privacy posed by present
DNA identification technology and concluded that the dire warnings of other
commentators are unwarranted. Id. at 93-100.

148. See DNA TECHNOLOGY, supra note 2, at 114 (explaining why "[e]ven
simple information about identity requires confidentiality"); Burk, supra note 104,
at 90 (indicating that banding pattern produced by DNA analysis is useful
only for identification purposes). In fact, the Commonwealth of Virginia con-
ducted the DNA testing at issue in Jones specifically in order to identify the pris-
oners genetically. See VA. STAT. ANN. § 19.2-310.2 (authorizing blood samples to
be taken for DNA testing "to determine identification characteristics specific to
the person"). But see Jones v. Murray, 962 F.2d 302, 306 (4th Cir.) (recognizing
that DNA analysis results contain information concerning identity but asserting
that once arrested, prisoner no longer has any protected privacy interest in his
or her identity), cert. denied, 113 S. Ct. 472 (1992).

149. Skinner v. Railway Labor Executives' Ass'n, 489 U.S. 602, 619-20
(1989) (using "special needs" test to uphold post-accident blood and urine drug
tests of railway employees); National Treasury Employees Union v. Von Raab,
489 U.S. 656, 665-66 (1989) (using "special needs" test to uphold blood and
urine drug tests of Customs officials involved in drug interdiction or required to
carry firearms).

150. NATIONAL RESEARCH COUNCIL, DNA TECHNOLOGY IN FORENSIC SCi-
ENCE (1992). For an initial assessment of this report, see DON J. DeBenedictis,
of DNA analyses for use in later criminal investigations.\textsuperscript{151} The authors of DNA Technology compared DNA profiles to latent fingerprints in order to "identify key issues pertinent to the establishment of DNA data[bases]."\textsuperscript{152} The report identified several features that distinguish DNA profiles from latent fingerprints.\textsuperscript{153} First, the authors noted that bodily fluids, or other DNA testable material, are found at far fewer crime scenes than latent fingerprints.\textsuperscript{154} Second, unlike fingerprints, the pattern on the autoradiograph that constitutes the DNA profile varies with the method of testing.\textsuperscript{155} Third, while the amount of information available from a latent fingerprint varies with the amount of evidence recovered, the amount of information available from DNA testable evidence varies instead with the test applied.\textsuperscript{156} Fourth, as DNA analysis now stands, fingerprints are more individual than DNA profiles.\textsuperscript{157} Fifth, obtaining fingerprints is far less "intrusive, costly and difficult" than taking a blood sample for DNA analysis.\textsuperscript{158} Finally, DNA analysis represents a greater intrusion on an individual than fingerprinting and can provide much greater personal information.\textsuperscript{159}

\textsuperscript{151} DNA Technology, supra note 2, at 111-30. Although DNA Technology mentions the possibility of DNA analyses for the entire population being stored in databases, this Note focuses only on databases of DNA test results from known offenders. See id. at 121-22 (rejecting arguments in favor of database of DNA profiles from all members of general population).

\textsuperscript{152} Id. at 111.

\textsuperscript{153} Id. at 112-13.

\textsuperscript{154} Id. at 112. As a result, latent fingerprints will be relevant evidence in a greater variety of crimes. Id. However, where present, DNA identification evidence is likely to be far more inculpatory because the presence of the suspect's bodily fluids at the crime scene is more difficult to assign to an innocent cause. Id.

\textsuperscript{155} Id. The authors further note that the profiles produced by different tests cannot be readily translated for comparison. Id. To be as constant and complete a physical pattern as a fingerprint, a DNA analysis would have to be capable of sequencing the entire three billion-gene sequence of an individual's DNA. Id.

\textsuperscript{156} Id. at 112-13 (explaining that while amount of fingerprint evidence depends on portion of finger(s) indicated by prints found, amount of DNA evidence depends on number of polymorphisms tested for).

\textsuperscript{157} Id. at 113. For a discussion of the reasons why the weight of DNA identification evidence must be expressed as the probability of a coincidence and of the difficulties associated with the statistical assumptions underlying that probability, see supra notes 113-21 and accompanying text.

\textsuperscript{158} DNA Technology, supra note 2, at 113 (noting far less training required for persons taking fingerprints as compared with those taking blood samples and performing DNA analysis). On the other hand, the authors of DNA Technology note further that while obtaining DNA profiles is more costly than obtaining fingerprints, computerization of DNA profiles for rapid comparison within a database is relatively inexpensive. Id.; see id. at 117-18 (performing cost/benefit analysis of DNA databanks).

\textsuperscript{159} Id. at 117-18. For a discussion of the information conveyed by DNA analysis, see supra notes 143-49 and accompanying text. The authors of DNA Technology emphasize the threat to privacy posed by a computerized database of DNA profiles. Id. at 114 ("DNA identification information could be misused to
Taking rapidly changing DNA technology into account, the authors of DNA Technology considered the creation of a national database unwarranted at that time because they believed that present RFLP technology would shortly be replaced by new technology that would be cheaper, simpler and easier to automate but wholly incompatible with RFLP. The authors of DNA Technology also found that in view of the expense of creating and maintaining DNA databases, "[t]o maximize the 'return per sample,' one should concentrate on persons convicted of crimes with documented high rates of recidivism." Based on their analysis of the available recidivism statistics, the authors of DNA Technology concluded that "a DNA profile databank would thus be valuable primarily in investigating forcible rape" and ought to be made up of profiles of violent sex offenders and unknown subjects. In Jones v. Murray, the United States Court of Appeals for the Fourth Circuit faced the issue of whether the government's interest in creating a database of DNA profiles of all convicted felons justified non-consensual testing in order to create such a database.

search and correlate criminal-record databanks or medical-record databanks.")]. They recommend that "[g]uidelines for release of DNA samples and disclosure of DNA typing information . . . be designed to safeguard the rights of persons who, for one reason or another, get involved in a DNA typing" and cited provisions of the Virginia law at issue in Jones as an example of legislative attempts to deal with the problem. Id. (citing VA. CODE ANN. § 19.2-31.6 (Michie 1990)).

Id. at 116. They warn that "[p]remature development of a national databank based on current RFLP typing methods runs the risk of perpetuating a 'dinosaur' technology in the face of better techniques." Id.

Id. at 118. The authors of DNA Technology further contend that "DNA profile databanks containing profiles of criminal offenders must be justified on the basis of the likelihood of recidivism." Id.

Id. at 120. The authors of DNA Technology noted the high rates of recidivism indicated by a Bureau of Justice Statistics study of prisoners released in 1983. Id. at 118-20 (citing ALLEN J. BECK & BERNARD E. SHIPLEY, BUREAU OF JUSTICE STATISTICS SPECIAL REPORT: RECIDIVISM OF PRISONERS RELEASED IN 1983 1, 3 (1989)). They proceeded to a two-part analysis of whether these statistics justified the inclusion of DNA profiles of all convicted persons in a database. Id. at 119-20 (answering two questions: "What fraction of crimes committed by repeat offenders do not themselves lead to rearrest and reconviction?" and "What fraction would end in rearrest and reconviction if a DNA profile databank were available?"). Initially, the authors of DNA Technology noted that rape is the exception to the general observation 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 perpetrator's own bodily fluids." Id. at 120. The authors of DNA Technology then concluded that their analysis of the recidivism statistics justified "the development of a databank of DNA profiles of unknown subjects (open cases) and of offenders convicted of violent sex crimes." Id.

Id. at 303.

161. Id. at 118. 162. Id. at 119-20.
III. Analysis

A. The Reasoning of the Jones Majority

In Jones v. Murray, the court held that “the Fourth Amendment does not require . . . individualized suspicion before blood can be taken from incarcerated felons for the purpose of [later] identifying them.” In Jones prisoners challenged the constitutionality of section 19.2-310.2 of the Virginia Code, which required prisoners convicted of felonies on or after July 1, 1990, to submit to blood testing for DNA analysis “to determine identification characteristics specific to the person.” Six prisoners, represented by an attorney from the Post Conviction Assistance Project of the University of Virginia School of Law, assisted by three third-year law students, asserted that involuntary extraction of blood for DNA analysis constituted an unreasonable search prohibited by the Fourth Amendment.

The prisoner-plaintiffs argued that in order to be reasonable under the Fourth Amendment, a search for law enforcement purposes must be based upon some degree of individualized suspicion. They further argued that the government’s generalized interest in improving identification techniques based solely on recidivism statistics was insufficient to justify testing all prisoners convicted of felonies. In response, the Commonwealth of Virginia contended that because the DNA database is

165. Id. at 302.
166. Id. at 306-07.
167. Id. at 303. Section 19.2-310.2 of the Virginia Code provides:

Blood sample required for DNA analysis upon conviction of a felony. — Every person convicted of a felony on or after July 1, 1990, and every person convicted of a felony offense under Article 7 (§ 18.2-61 et seq.) of Chapter 4 of Title 18.2 who was incarcerated on July 1, 1989, shall have a sample of his blood taken for DNA (deoxyribonucleic acid) analysis to determine identification characteristics specific to the person. The analysis shall be performed by the Division of Forensic Science, Department of General Services. The identification characteristics of the profile resulting from the DNA analysis shall be stored and maintained by the Division in a DNA data bank and shall be made available only as provided in § 19.2-310.5.

After July 1, 1990, the blood sample shall be taken prior to release from custody.

Notwithstanding the provisions of § 53.1-159, any person convicted of a felony who is in custody after July 1, 1990, shall provide a blood sample prior to his release. Every person so convicted after July 1, 1990, who is not sentenced to a term of confinement shall provide a blood sample as a condition of such sentence.

168. VA. CODE ANN. § 19.2-310.2.
169. Jones, 962 F.2d at 303.
170. Id. at 305.
171. Id. The prisoner-plaintiffs argued that without a requirement of individualized suspicion, law enforcement officials could justify searches of other classes of persons, for example those suffering from mental disease, based on recidivism statistics alone. Id.
intended to aid in solving future crimes, it is impossible to demonstrate individualized suspicion in this situation.\textsuperscript{172} The Commonwealth further argued that its interest in establishing a database of DNA test results was a “special need” under Skinner that justified the searches without need for any individualized suspicion.\textsuperscript{173}

The Jones majority responded to these arguments by choosing to view Fourth Amendment cases concerning prisoners as a discrete category to which the usual requirement of probable cause did not apply, dismissing the “special needs” test in a footnote.\textsuperscript{174} In order to justify its conclusion that the Fourth Amendment does not require individualized suspicion for the state to conduct a blood test on its prisoners,\textsuperscript{175} the majority suggested that prisoners have few, if any, rights under the

\begin{quote}
\textsuperscript{172} Id. Similarly, in Skinner v. Railway Labor Executives’ Ass’n, the Court pointed out that a requirement of individualized suspicion was impractical in the circumstances. 489 U.S. 602, 631 (1989). The Court stated: “It would be unrealistic and inimical to the Government’s goal of ensuring safety in rail transportation, to require a showing of individualized suspicion in these circumstances.” Id. The Skinner Court upheld suspicionless drug tests of railroad employees following an accident. Id. at 693-94.

In its argument in Jones, the Commonwealth relied on two studies of released prisoners that demonstrated high rates of recidivism among convicted felons. Jones, 962 F.2d at 306 (citing \textit{Allen J. Beck} & \textit{Bernard Shiple}, \textit{BUREAU OF JUSTICE STATISTICS}, \textit{SPECIAL REPORT: RECIDIVISM OF PRISONERS RELEASED IN 1983}, 1, 3 (1989); \textit{DEPARTMENT OF CRIMINAL JUSTICE SERVS.}, \textit{VIOLENT CRIME IN VIRGINIA}, 1, 30-33 (1989)). The Commonwealth used these studies to support its argument that a database of DNA identifications of convicted felons might aid in identifying the perpetrators of future crimes. Jones, 962 F.2d at 306. The court noted that one federal study indicated that 62.5\% of prisoners released in 1983 were rearrested for a felony or serious misdemeanor within three years. \textit{Id.} (quoting \textit{Allen J. Beck} & \textit{Bernard Shiple}, \textit{BUREAU OF JUSTICE STATISTICS}, \textit{SPECIAL REPORT: RECIDIVISM OF PRISONERS RELEASED IN 1983}, 1, 1 (1989)). The Jones court further noted that “[t]he Virginia statistics are not significantly different.” \textit{Id.} (citing \textit{DEPARTMENT OF CRIMINAL JUSTICE SERVS.}, \textit{VIOLENT CRIME IN VIRGINIA}, 1, 30-31 (1989)).

\textsuperscript{173} Id. at 305. The District Court in Jones had upheld the Virginia law based on its conclusion that blood testing of prisoners for identification purposes fell within the “special needs” test. Jones v. Murray, 763 F. Supp. 842, 844-48 (W.D. Va. 1991), aff’d in part, 962 F.2d 302 (4th Cir.), cert. denied, 113 S. Ct. 472 (1992).

\textsuperscript{174} Jones, 962 F.2d at 307 & n.2 (noting that Fourth Amendment prisoners’ rights cases “comprise a separate category of cases to which the usual per se requirement of probable cause does not apply” and that there was “no cause to address whether the so-called ‘special needs’ exception, [to the probable cause requirement] . . . applied in this case”). The Jones majority cited no authority for the proposition that the probable cause requirement does not apply to searches of prisoners, but found support for its position in the fact that the Supreme Court had never expressly required a finding of some degree of individualized suspicion for any law enforcement search. \textit{Id.}

\textsuperscript{175} Id. at 306. The majority first acknowledged that under Schmerber v. California, a blood test is a search under the Fourth Amendment. \textit{Id.} (citing Schmerber v. California, 384 U.S. 757 (1966)). The court also noted that it knew of no case requiring any degree of suspicion for a limited search conducted by government officials for the purpose of identifying a prisoner. \textit{Id.}
Fourth Amendment.\textsuperscript{176} The majority cited \textit{Bell v. Wolfish}\textsuperscript{177} and \textit{Hudson v. Palmer}\textsuperscript{178} as examples of the degree to which Fourth Amendment protections can be lost by an individual’s contact with the criminal justice system.\textsuperscript{179} Following these examples, the \textit{Jones} court held that in a prison “blood testing can be reasonable under the Fourth Amendment . . . where the slight intrusion is outweighed by the governmental interest advanced by the intrusion.”\textsuperscript{180}

The court then applied this balancing test to determine the reasonableness of non-consensual blood testing for DNA analysis.\textsuperscript{181} First, the \textit{Jones} court identified, and minimized, the intrusion on the prisoners’ privacy interests.\textsuperscript{182} Next, the majority emphasized the importance of the government interest in creating a database of DNA test results to aid law enforcement in solving future crimes.\textsuperscript{183} In response to the prisoner-plaintiffs’ argument regarding the small statistical likelihood of non-violent felons committing future crimes in which DNA evidence could be used, the majority suggested potential additional uses of DNA identification information, such as identifying felons who had changed their app-

\textsuperscript{176} Id. ("With the person’s loss of liberty upon arrest comes the loss of at least some, if not all, rights to personal privacy otherwise protected by the Fourth Amendment."); see \textit{Bell v. Wolfish}, 441 U.S. 520, 556-57 (1979) ("It may well be argued that a person confined in a detention facility has no reasonable expectation of privacy with respect to his room or cell and that therefore the Fourth Amendment provides no protection for such a person.").

\textsuperscript{177} Bell v. Wolfish, 441 U.S. 520 (1979).


\textsuperscript{179} Jones, 962 F.2d at 306 (holding that prisoner can have no reasonable expectation of privacy in prison cell (citing Hudson v. Palmer, 468 U.S. 517, 530 (1984)); see Bell, 441 U.S. at 559-60 (upholding visual body cavity searches of pretrial detainees).

\textsuperscript{180} Jones, 962 F.2d at 307. In creating this test, the majority considered \textit{Dunn v. White}, in which the United States Court of Appeals for the Tenth Circuit upheld taking blood samples from prisoners without their consent in order to test for the presence of Human Immunodeficiency Virus (HIV). Dunn v. White, 880 F.2d 1188, 1196-97 (10th Cir. 1989), cert. denied, 493 U.S. 1059 (1990). In Dunn, the government interest held to outweigh the prisoner’s privacy interest had a penal purpose: to gather information on and to prevent the spread of AIDS in the prison population. Id. at 1195. The Jones dissent correctly noted that the Commonwealth had asserted no similar penal considerations in that case. Jones, 962 F.2d at 313 n.2 (Murnaghan, J., concurring in part and dissenting in part). Furthermore, a careful reading reveals that the Dunn court applied the “special needs” test from \textit{Skinner}, which the Jones court stated did not apply. Compare Dunn, 880 F.2d at 1193 with Jones, 962 F.2d at 307 n.2. For a complete discussion of Dunn v. White, see supra notes 77-85 and accompanying text.

\textsuperscript{181} Jones, 962 F.2d at 307.

\textsuperscript{182} Id. The majority emphasized that the procedure “involves virtually no risk, trauma, or pain.” Id. (quoting Skinner v. Railway Labor Executives’ Ass’n, 489 U.S. 602, 625 (1989) (quoting Schmerber v. California, 384 U.S. 757, 771 (1966))).

\textsuperscript{183} Id. Citing no authority, the majority suggested that where traditional methods of identification failed, DNA testing would provide a “dramatic new tool for the law enforcement effort to match suspects and criminal conduct.” Id.
In response to the prisoner-plaintiffs' argument that the government's interest was more compelling as applied to violent felons than non-violent felons, the court stated: "It is not for us to weigh the advantages of one method of identification over another which is selected by the Commonwealth."185 Citing Michigan Department of State Police v. Sitz186 and Bell v. Wolfish,187 the Jones court reasoned that particular law enforcement techniques need not be highly effective, provided that the intrusion on constitutionally-protected privacy interests was small.188 Balancing the governmental and privacy interests accordingly, the court concluded that the intrusion represented by DNA testing was justified by the governmental interest and thus did not offend the Fourth Amendment.189

To bolster this conclusion, the Jones majority analogized DNA testing to fingerprinting.190 The court reasoned that at arrest a person's identity becomes of legitimate interest to law enforcement officials and therefore he or she can no longer claim a reasonable expectation of privacy in it.191 The court concluded that because prisoners have diminished expectations of privacy by virtue of their incarceration, DNA testing of prisoners was an acceptable law enforcement technique which,

184. Id. ("Even a suspect with altered physical features cannot escape the match that his DNA might make with a sample contained in a DNA bank . . . ").
185. Id. at 308. The majority suggested two reasons for allowing DNA tests of non-violent felons: that DNA test results might be useful for identifying criminal suspects who attempt to conceal their identities and that as DNA testing became more common, and law enforcement officials became more aware of its potential, it could be used in solving crimes other than murder and rape. Id.
188. Jones, 962 F.2d at 308 (holding that effectiveness of a particular law enforcement technique need not be great "where the objective is significant and the privacy intrusion limited," citing Michigan Dep't of State Police v. Sitz, 496 U.S. 444, 454-56 (1990) and Bell v. Wolfish, 441 U.S. 520, 559 (1979)).
189. Id. at 307 (weighing "minor" intrusion on prisoners' privacy against government's interest in "preserving a permanent identification record of convicted felons"). The court concluded that Virginia's interest outweighed the prisoners' interests. Id.
190. Id. The court stated that "governmental justification for this form of identification, therefore relies on no argument different in kind from that traditionally advanced for taking fingerprints . . . , but with additional force because of the potentially greater precision of DNA sampling and matching methods." Id. For another perspective on the comparison between DNA identification evidence and fingerprints by the authors of DNA Technology, see supra notes 152-64 and accompanying text.
191. Jones, 962 F.2d at 306. The court referred to the "universal approba-

like fingerprinting, did not violate the Fourth Amendment.\textsuperscript{192}

In his separate opinion,\textsuperscript{193} Judge Murnaghan disagreed with the majority in three respects. First, he concluded that the majority's reasoning unnecessarily reduced a prisoner's Fourth Amendment protection to nearly zero.\textsuperscript{194} Second, Judge Murnaghan quarreled with the majority's interpretation of the prisoners' rights cases and suspicionless search cases to authorize use of a simple balancing test to determine the reasonableness of a non-consensual blood test in the prison context.\textsuperscript{195} Third, Judge Murnaghan concluded that under proper Fourth Amendment analysis, the state had failed to justify the DNA testing of convicted non-violent felons.\textsuperscript{196}

Judge Murnaghan's first point of difference with the majority con-

\textsuperscript{192} Id. at 306-07. "As with fingerprinting, therefore, we find that the Fourth Amendment does not require an additional finding of individualized suspicion before blood can be taken from incarcerated felons for the purpose of identifying them." \textit{Id.}

\textsuperscript{193} Id. at 311 (Murnaghan, J., dissenting in part and concurring in part). Judge Murnaghan concurred in the majority holding that Virginia's DNA testing statute operated as an ex post facto law in purporting to alter Virginia's mandatory parole statute. \textit{Id.} (Murnaghan, J., concurring in part and dissenting in part). He also concurred in the majority's holding that the Virginia mandatory DNA testing statute was constitutional as applied to violent felons. \textit{Id.} (Murnaghan, J., concurring in part and dissenting in part). Judge Murnaghan's dissent was limited to the majority's holding that the statute was constitutional as applied to non-violent felons. \textit{Id.} (Murnaghan, J., concurring in part and dissenting in part) (stating that "I must respectfully dissent from the majority's determination of the constitutionality of the statute as applied to prisoners convicted of non-violent crimes").

\textsuperscript{194} Id. (Murnaghan, J., concurring in part and dissenting in part) (noting "majority's strikingly truncated view of the Fourth Amendment protections afforded to a convicted felon"); \textit{cf. id.} at 306 (majority opinion) ("With the prisoner's loss of liberty upon arrest comes the loss of at least some, if not all, rights to personal privacy otherwise protected by the Fourth Amendment.") (emphasis added). The Supreme Court has never gone so far. \textit{See} Hudson v. Palmer, 468 U.S. 517, 528 (1984) (implying that prisoner has expectation of privacy although it must always yield to \"paramount interest in institutional security\")\textsuperscript{196}. Moreover, the \textit{Jones} court was bound by \textit{Schmerber v. California}, which held that a blood test is a search under the Fourth Amendment. 384 U.S. 757, 767 (1966) (Blood tests \"plainly constitute searches of \'persons,' \ldots within the meaning of \[the Fourth\] Amendment.").

\textsuperscript{195} \textit{Jones}, 962 F.2d at 311-13 (Murnaghan, J., concurring in part and dissenting in part).

\textsuperscript{196} Id. at 311 (Murnaghan, J., concurring in part and dissenting in part). He summarized his position as follows:

To the extent that the majority opinion upholds the Virginia DNA testing procedure as applied to violent felons, \ldots I concur in the decision. But I must respectfully dissent from the majority's determination of the constitutionality of the statute as applied to prisoners convicted of non-violent crimes. Prisoners do not lose an expectation of privacy with regard to blood testing, and the Commonwealth's articulated interest in the testing of non-violent felons does not counter-balance the privacy violation involved in the procedure.

\textit{Id.} (Murnaghan, J., concurring in part and dissenting in part).
cerned the weight of the prisoners' asserted privacy interest. Judge Murnaghan interpreted Supreme Court precedent to indicate that prisoners retained those Fourth Amendment rights that are not inconsistent with their incarceration. He contended that the majority had read Bell and Hudson too broadly. In support of this view, Judge Murnaghan quoted the Supreme Court in Skinner: "[I]t is obvious that

197. Id. at 312 (Murnaghan, J., concurring in part and dissenting in part) ("[B]lood testing] violates a privacy interest that even a prisoner, living in close quarters under constant security surveillance, reasonably can expect to enjoy.").

198. Id. at 312-13 (Murnaghan, J., concurring in part and dissenting in part). "[F]or prisoners [must] be accorded those rights not fundamentally inconsistent with imprisonment itself or incompatible with the objectives of incarceration." Id. at 313 (Murnaghan, J., concurring in part and dissenting in part) (quoting Hudson v. Palmer, 468 U.S. 517, 523 (1984)). Judge Murnaghan distinguished a prisoner's privacy interest in being free from non-consensual DNA analysis from those privacy interests that are relinquished in the prison context because "no practical penal concern justifies the departure involved in the DNA [testing] procedure." Id. at 312 (Murnaghan, J., concurring in part and dissenting in part). Judge Murnaghan acknowledged, however, that Supreme Court precedent existed indicating that in some situations "a private citizen's expectation of privacy diminishes, or disappears altogether." Id. at 312 & n.1 (Murnaghan, J., concurring in part and dissenting in part).

199. Id. at 312 (Murnaghan, J., concurring in part and dissenting in part). The majority reasoned that because body cavity searches were upheld in Bell, and random searches of prison cells were upheld in Hudson, that prisoners' residual privacy protection was minimal. Id. at 306 (Murnaghan, J., concurring in part and dissenting in part). Judge Murnaghan, however, pointed out that the Court in Bell had reiterated that prisoners retained some privacy rights. Id. at 312 (Murnaghan, J., concurring in part and dissenting in part) (citing Bell v. Wolfish, 411 U.S. 520, 560 (1979)). But see Bell, 411 U.S. at 556-57 (noting possible argument that prisoners have no reasonable expectations of privacy and assuming for sake of argument that prisoners retain some privacy rights).

Judge Murnaghan further noted the majority's conclusion that under Hudson prisoners lose Fourth Amendment protection from all routine searches. Id. at 312 (Murnaghan, J., concurring in part and dissenting in part) (citing Hudson v. Palmer, 468 U.S. 517 (1984)). He disagreed with the majority's extension of that conclusion in applying the Hudson standard to searches of prisoners' bodily fluids. Id. (Murnaghan, J., concurring in part and dissenting in part). Judge Murnaghan considered the majority's reliance on Hudson misplaced because prisoners retained a reasonable expectation of privacy in their bodily fluids, which was not inconsistent with their incarceration. Id. at 312-13 (Murnaghan, J., concurring in part and dissenting in part).

In his dissent, Judge Murnaghan also disagreed with the majority's reliance on Griffin v. Wisconsin, 483 U.S. 868 (1987). Jones, 962 F.2d at 313 (Murnaghan, J., concurring in part and dissenting in part). The majority cited Griffin for the proposition that probationers "lose the protection of the Fourth Amendment with respect to their right of privacy against searches of their home pursuant to an established program to ensure rehabilitation and security." Id. at 306 (citing Griffin v. Wisconsin, 483 U.S. 868, 880 (1987)). Judge Murnaghan distinguished the searches at issue in Griffin v. Wisconsin, 483 U.S. 868, 880 (1987), which were carried out pursuant to reasonable suspicion, from the searches at issue in Jones, which were conducted without any individualized suspicion whatsoever. Id. at 313 (Murnaghan, J., concurring in part and dissenting in part) (noting that both sides had conceded that no individualized suspicion had motivated searches at issue).
this physical invasion [a blood test] penetrating beneath the skin, infringes an expectation of privacy that society is prepared to recognize as reasonable. 200 Unlike the majority, Judge Murnaghan believed that even a prisoner does not lose a reasonable expectation of privacy beneath the skin. 201

Judge Murnaghan's second point of departure concerned the appropriate test to apply to the testing at issue in Jones. 202 Unlike the majority, which applied a simple balancing test derived from the prisoner cases, Judge Murnaghan concluded that the correct test to apply was that used in Sitz. 203 The Sitz test consists of three factors to be balanced: 1) the privacy interest of the individual, 2) the state's interest in the particular law enforcement technique and 3) the degree to which the technique advances the state's interest in law enforcement. 204 Using this test, Judge Murnaghan agreed with the majority that DNA testing was justified for violent felons, but disagreed regarding testing of non-violent felons. 205

200. Jones, 962 F.2d at 312 (Murnaghan, J., concurring in part and dissenting in part) (quoting Skinner v. Railway Labor Executives' Ass'n, 489 U.S. 602, 616 (1989) (bracketed material added by Judge Murnaghan)). Judge Murnaghan attributed to Skinner a determination that "an individual has a reasonable expectation of privacy within one's own body" and found that it "apply[d] equally to prisoners, unless the prisoner's privacy right is incompatible with the objectives of incarceration." Id. (Murnaghan, J., concurring in part and dissenting in part).

201. Id. at 311 (Murnaghan, J., concurring in part and dissenting in part). Judge Murnaghan made his point emphatically: Although it has been established that incarcerated individuals, particularly because of a partial loss of an expectation of privacy, must carry on their affairs under a significantly limited umbrella of protections against most searches, there exists no blanket authorization of searches involving intrusions under the skin, for which no individual, whether in prison or out, loses a reasonable expectation of privacy.

Id. (Murnaghan, J., concurring in part and dissenting in part).

202. Id. at 313 (Murnaghan J., concurring in part and dissenting in part) (advocating use of three-prong Sitz test). For a discussion of the test applied by the majority, see supra notes 165-92 and accompanying text.

203. Jones, 962 F.2d at 307 & n.2 (majority announcing simple balancing test); id. at 313 (Murnaghan, J., concurring in part and dissenting in part) (advocating use of Sitz test). Judge Murnaghan noted that "[i]t is with a reasoned application of the Sitz standard, and not with a disturbing restriction of the Fourth Amendment protections afforded to the nation's prisoners, that the DNA testing procedure, as applied to felons convicted of violent crime, may be justified." Id. (Murnaghan, J., concurring in part and dissenting in part).

204. Michigan Dep't of State Police v. Sitz, 496 U.S. 444, 455 (1990). Judge Murnaghan described the Sitz test: "Justification for searches of these individuals must be based, as must all searches of citizens in a free society still clinging to disappearing Fourth Amendment protections, on a balancing of the privacy interest involved against the state interest in the search to determine which interest is more compelling." Jones, 962 F.2d at 313 (Murnaghan, J., concurring in part and dissenting in part).

205. Jones, 962 F.2d at 315 (Murnaghan, J., concurring in part and dissenting in part). Regarding violent felons, Judge Murnaghan found a "sufficiently
Judge Murnaghan's third point of departure from the majority concerned the state's attempted justification of the intrusion on the prisoners' privacy interests. Judge Murnaghan stressed that the only interest offered by the Commonwealth to justify the testing of non-violent felons was administrative ease. He also emphasized that DNA testing of non-violent felons was likely to have only a negligible benefit for solving future crimes. He referred to statistical evidence that indicated that although DNA-testable material, such as blood or other bodily fluids, is found at 30% of crime scenes, 97% of the cases in which DNA evidence identified a criminal were murders or rapes. There-
fore, as applied to non-violent felons, Judge Murnaghan considered the asserted governmental interest in administrative convenience wholly insufficient to justify the intrusion represented by DNA testing.210

C. Where the Jones Court Went Wrong

There are three major difficulties with the Jones court's resolution of the issue of the constitutionality of non-consensual DNA testing of prisoners. First, instead of using the "special needs" test, the Jones majority looked only to prisoner cases and applied a simple balancing test. Second, even within this test, the court unduly minimized the prisoners' privacy interests at stake. Finally, the reasoning of the Jones majority relied on an uncritical analogy between fingerprinting and DNA testing as methods of identification.

Rather than apply the "special needs" test from Skinner to determine when a search may be constitutionally conducted without individualized suspicion, the Jones majority chose to restrict its frame of reference to the prisoner cases and to further narrow the protection afforded prisoners by the Fourth Amendment.211 Although the Supreme Court has not addressed the issue of the constitutionality of blood testing for DNA analysis, the Fourth Circuit could have followed the Tenth Circuit's opinion in Dunn v. White212 and applied the "special needs" test.213 The Jones court could even have reached the same conclusion by applying the "special needs" test.214 The "special needs" test may not afford the opportunity to recover relevant biological evidence that will allow the police to identify an unknown suspect—i.e. the perpetrator's own bodily fluids." Id. (noting that rape is major exception and that useful biological samples are also recovered in "a small minority of homicides").

210. Jones, 962 F.2d at 315 (Murnaghan, J., concurring in part and dissenting in part).

211. For a discussion of the majority's reasoning, see supra notes 163-92 and accompanying text.


213. Skinner v. Railway Labor Executives' Ass'n, 489 U.S. 602, 619 (1989) (defining "special needs" test (citing Griffin v. Wisconsin, 483 U.S. 868 (1987))). The Court described the "special needs" test: "When faced with such special needs [that are beyond the normal needs of law enforcement,] we have not hesitated to balance the governmental and privacy interests to assess the practicality of the warrant and probable-cause requirements in the particular context." Id. For a further discussion of the "special needs" test, see supra notes 58-62.

214. See Jones v. Murray, 763 F. Supp. 842, 844-48 (W.D. Va. 1991) (upholding compulsory testing statute at issue using "special needs" test (Jones I), aff'd in part, 962 F.2d 302 (4th Cir.), cert denied., 113 S. Ct. 472 (1992). To uphold the Jones statute under the "special needs" test, the court could first have justified DNA testing of felons in order to create a database, which would aid in identifying criminals using new DNA technology, as a "special need" of law enforcement. See id. at 845 (holding creation of database "can be classified as a special need even if the [database] will be used in solving future crimes"); see also Griffin v. Wisconsin, 483 U.S. 872, 873-74 (1987) (giving examples of such
be appropriate to the Jones facts, however, because the Supreme Court has implicitly suggested that it is restricted to the civil setting. Nonetheless, expanding the "special needs" test to the criminal context, rather than establishing a new simple balancing test for the prison setting, would have been a less drastic change and would have provided better guidance for future courts faced with this issue.

Aside from the test it ultimately applied, the Jones court's reasoning had a second, graver flaw: it unduly minimized the prisoners' privacy interests and overstated the governmental interest with respect to non-violent felons. Judge Murnaghan found that non-violent felons were "not significantly more likely to commit a violent crime in the future than . . . member[s] of the general population." Under the "special needs" including "operation of a probation system, . . . of a school, government office or prison, or . . . supervision of a regulated industry". See generally People v. Wesley, 533 N.Y.S.2d 643, 644 (Albany County Ct. 1988) (describing forensic DNA testing as potentially "greatest advance in the 'search for truth,' and the goal of convicting the guilty and acquitting the innocent, since the advent of cross-examination"). aff'd, 589 N.Y.S.2d 197 (App. Div. 1992), aff'd, No. 18, 1994 WL 99513 (N.Y. Mar. 29, 1994); GENETIC WITNESS, supra note 2, at 17 (discussing advantages of DNA identification evidence); Longobardi, supra note 3, at 350-57 (advocating creation of national DNA database); cf. Tighten Rules for DNA Printing, NEWSDAY, June 14, 1992, sec. Currents at 27 (editorial generally supporting Governor's proposal for creation of New York state DNA database, but advocating mandatory rather than voluntary compliance with strict procedural standards).

Once such a "special need" is established, the court then must balance the government's interest against the privacy interest being invaded. Skinner, 489 U.S. at 619 (citing Griffin v. Wisconsin, 483 U.S. 868, 873 (1987))). This is essentially the same balancing that the Jones majority undertook. Jones v. Murray, 962 F.2d 302, 310-11 (4th Cir.) (holding that Commonwealth's interest in law enforcement outweighs prisoners' privacy interests using simple balancing test), cert. denied, 113 S. Ct. 472 (1992); cf. Jones I, 763 F. Supp. at 848 (same, using "special needs" test). For a discussion of the Jones majority's analysis of the interests involved, see supra notes 165-92 and accompanying text.

215. National Treasury Employees Union v. Von Raab, 489 U.S. 656, 668 (1989) (applying "special needs" test and concluding that Fourth Amendment did not prohibit routine drug testing of Customs employees directly engaged in drug interdiction or required to carry firearms). In reaching its decision, the Von Raab Court pointed to the fact that the results of the drug tests at issue could not be used in a criminal prosecution. Id. (noting that test results could be used in criminal prosecution only with employee's consent). The Von Raab Court stated: "Our cases teach, however, that the probable-cause standard 'is peculiarly related to criminal investigation.'" Id. at 667 (quoting Colorado v. Bertine, 479 U.S. 367, 371 (1987) (quoting South Dakota v. Opperman, 428 U.S. 364, 370 n.5 (1976))). Moreover, this consideration would seem to mitigate in favor of providing prisoners with more, not less, Fourth Amendment protection.

216. See Jones, 962 F.2d at 311 (Murnaghan, J., concurring in part and dissenting in part) (concluding that non-violent felons' privacy interests outweigh state interest in DNA testing).

217. Id. at 313-14 (Murnaghan, J., concurring in part and dissenting in part). For Judge Murnaghan's discussion of the recidivism statistics cited by the parties, see id. at 314-15 (Murnaghan, J., concurring in part and dissenting in part).
needs” test and Judge Murnaghan’s analysis of the countervailing interests, the Virginia statute at issue in Jones should have been upheld as applied to violent felons but struck down as applied to non-violent felons because there is simply no statistical basis sufficient to justify the attendant invasion of the privacy interests of non-violent felons.

A third difficulty with Jones was the court’s unquestioning acceptance of the analogy between forensic DNA analysis and fingerprinting. The court thus glossed over the procedural and statistical problems associated with forensic DNA analysis. These problems have been the subject of much scholarly debate and deserve careful consideration by any court addressing the constitutionality of creating a DNA database. Moreover, as noted by the authors of DNA Technology, blood testing and the ensuing DNA analysis represent a much greater intrusion upon individual privacy than routine fingerprinting as even the Jones majority admitted. As the comparison of DNA profiling and latent fingerprints demonstrates, the analogy oversimplifies the strengths and weaknesses of the two technologies. Simply because DNA testing is a technological advance beyond fingerprinting and photographs due to “the potentially greater precision of DNA sampling and matching methods,” the governmental interest in performing these tests does not, as the Jones majority asserted, necessarily outweigh the greater intrusion that DNA testing represents.

Rather than recognize these fundamental differences between fin-

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218. Id. at 306-07 (“As with fingerprinting, therefore, we find that the Fourth Amendment does not require ... individualized suspicion before blood can be taken from incarcerated felons for the purpose of identifying them.”).

219. For a discussion of the procedural sources of error in forensic DNA analysis, see supra notes 107-12 and accompanying text. For a discussion of the scientific debate over the statistical underpinnings of DNA identification evidence, see supra notes 113-20 and accompanying text.

220. See United States v. Porter, 618 A.2d 629, 635-44 (D.C. 1992) (analyzing in great detail defendant’s challenge to admission of DNA evidence, including lengthy discussion of statistical controversy surrounding forensic DNA evidence). For example, a Washington, D.C., trial court recently held a twenty-day hearing on the admissibility of DNA identification evidence during which “the judge heard testimony from eight expert witnesses, admitted over 110 exhibits, and received over 1,300 pages of briefs.” Id. at 630 (citing United States v. Porter, 120 DAILY WASH. L. REPTR. 477 (D.C. Super. Ct. 1991) and excluding DNA evidence in order and 93 page opinion).

221. DNA TECHNOLOGY, supra note 2, at 113.

222. Jones, 962 F.2d at 307 (recognizing that “search effected by the taking of a blood sample may be considered a greater intrusion than fingerprinting”); see Schmerber v. California, 384 U.S. 757, 779 (Douglas, J., dissenting in part) ("No clearer invasion of this right of privacy [recognized in Griswold v. Connecticut, 381 U.S. 479 (1965)] can be imagined than forcible bloodletting of the kind involved here.").

223. See DNA TECHNOLOGY, supra note 2, at 111-13. For a complete discussion of the comparison between latent fingerprints and DNA profiles found in DNA TECHNOLOGY, see supra notes 152-59 and accompanying text.

gerprinting and DNA testing, however, the Jones court utilized the fingerprinting analogy to suggest, then retreat from, the idea that DNA testing does not amount to a search under the Fourth Amendment.\textsuperscript{225} The Jones majority suggested that prisoners retain no reasonable expectations of privacy while incarcerated.\textsuperscript{226} Significantly, had the Jones court found that DNA testing did not represent an intrusion into a prisoner’s reasonable expectation of privacy, the DNA testing at issue would not have amounted to a “search”\textsuperscript{227} and the Fourth Amendment would have imposed no limitation on government action.\textsuperscript{228} The Supreme Court, however, has never gone so far.\textsuperscript{229}

V. Impact

When other courts address the question of whether non-consensual DNA testing statutes like the one at issue in Jones violate the Fourth Amendment, they will be faced with the alternatives of adopting the simple balancing test created by the Jones majority or the “special needs” test applied in Skinner.\textsuperscript{230} Given that the Supreme Court in Skinner defined the “special needs” test to determine the circumstances under which a governmental intrusion may be justified without a warrant or probable cause, there is little need to define a new test for this context. Similarly, because Jones unnecessarily further restricts the Fourth Amendment protections of prisoners, courts faced with similar issues in the future should hesitate to follow it in preference to Skinner.

\textsuperscript{225} See id. at 306-07.
\textsuperscript{226} Id. at 306 (“With the person’s loss of liberty upon arrest comes the loss of some, if not all, rights to personal privacy otherwise protected by the Fourth Amendment.”) (emphasis added).
\textsuperscript{227} Katz v. United States, 389 U.S. 347, 360-61 (1967) (Harlan, J., concurring) (concluding that physical or electronic intrusion into area where one has reasonable expectation of privacy is “search” in constitutional terms and is presumptively unreasonable unless conducted pursuant to search warrant).
\textsuperscript{228} See California v. Greenwood, 486 U.S. 35, 39-43 (1988) (holding that inspection of garbage left on street in opaque bags did not amount to constitutional search because respondents had no reasonable expectation of privacy in their garbage); Hudson v. Palmer, 468 U.S. 517, 525-26 (1984) (holding that Fourth Amendment was not violated by random searches of prison cells because prisoners have no reasonable expectations of privacy in their cells).
\textsuperscript{229} See Hudson, 468 U.S. at 528 (implying that prisoner has expectation of privacy although it must always yield to “paramount interest in institutional security”).
\textsuperscript{230} For a discussion of the reasoning of the Jones majority, see supra notes 165-92 and accompanying text. For a discussion of the “special needs” test, see notes 58-62 and accompanying text. In fact, as of the time of this writing, one other court has addressed the issue of the constitutionality of non-consensual DNA testing of convicted felons. State v. Olivas, 856 P.2d 1076 (Wash. 1993) (en banc). In Olivas, the Supreme Court of Washington held that the “special needs” test was preferable to the approach of the Jones majority to this issue. Id. at 1086. The court seemed to consider the constitutionality of these searches already determined by prior case law, including Schmerber and Skinner, and decided only the “approach” with which to reach this result. Id. at 1083-86, 1088.
Courts considering the constitutionality of DNA database statutes like the one at issue in *Jones* should also be cautious of allowing enthusiasm for new technology to override constitutional protections. Until forensic DNA testing has developed to the same level of reliability as fingerprinting, courts should bear in mind both the potential usefulness of DNA testing in solving future crimes and its technological limitations in terms of the crimes DNA testing is likely to aid in solving. In addition, as DNA technology improves, and provides more information about a suspect, the privacy interest compromised by DNA testing will become even stronger. Thus, courts ought not to establish excessively lenient standards authorizing testing.

The *Jones* court correctly pointed out that the ideal forum for the consideration of the concerns surrounding forensic DNA testing is the legislature. Legislatures drafting statutes similar to the one considered in *Jones* should be extremely careful to distinguish violent from non-violent felons. As Judge Murnaghan cogently argued in his dissent, given the tenuous statistical link between non-violent felons and future violent crimes it is only rational to draw a distinction between the two.

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231. See *Jones v. Murray*, 962 F.2d 302, 314-15 (4th Cir.) (Murnaghan, J., concurring in part and dissenting in part) (discussing statistical evidence of utility of forensic DNA testing and suggesting that Virginia's "DNA testing program will prove, perhaps, ill-advised"), *cert. denied*, 113 S. Ct. 472 (1992). For a discussion of the issues concerning the reliability of forensic DNA analysis, see *supra* notes 107-20 and accompanying text.

232. *Genetic Witness*, *supra* note 2, at 113 (acknowledging concern of opponents of DNA databases regarding expanded genetic testing).

233. *Jones*, 962 F.2d at 308 (“It is not for us to weigh the advantages of one method of identification over another which is selected by the Commonwealth.”).

234. For a discussion of Judge Murnaghan’s dissent, see *supra* notes 193-210 and accompanying text.