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CURRENT CONTROVERSIES IN THE USE OF DNA IN FORENSIC INVESTIGATIONS

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"It is the little details that are vital.
Little things make big things happen." - John Wooden[**]

Sherlock Holmes was the master of detail and would make stunning conclusions about a person's height, appearance, and weight by merely looking at a footprint in the dirt.[1] Current crime sleuths in shows like CSI and Dexter, however, make Holmes' conclusions look pedestrian by solving cases[2] through high-tech magic, quickly and without mistake.[3] In reality, about 40% of the scientific techniques employed on these productions are fictional, and most other methods are used in ways that criminalists only wish were accurate.[4]

Forensic science has advanced at a dizzying speed during the past few decades, and solving crimes has become almost futuristic in its

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** Lewis Howes, *10 Lessons for Entrepreneurs from Coach John Wooden*, FORBES (Oct. 19, 2012, 2:08 AM), https://www.forbes.com/sites/lewishowes/2012/10/19/10-lessons-for-entrepreneurs-from-coach-john-wooden/#f4282f116d54.

1. *Five Ways Sherlock Holmes Inspired Forensic Investigation*, FORENSIC OUTREACH (Feb. 26, 2014), https://forensicoutreach.com/library/5-ways-sherlock-holmes-inspired-forensic-investigation/.

2. Arun Rath, *Is the "CSI Effect" Influencing Courtrooms?*, NAT'L PUB. RADIO (Feb. 5, 2011, 7:30 PM), https://www.npr.org/2011/02/06/133497696/is-the-csi-effect-influencing-courtrooms.

3. N.J. Schweitzer & Michael J. Saks, *The CSI Effect: Popular Fiction About Forensic Science Affects the Public's Expectations About Real Forensic Science*, 47 JURIMETRICS J. 357, 358 (2007).

4. *Id.*

approach.[5] Techniques such as fingerprinting and blood splatter analyses now seem old fashioned.[6] These methods have been supplemented with automated fingerprint identification technology and video spectral comparators, which allow the police to immediately compare a fingerprint found at a crime scene with an extensive virtual database, and permit criminalists to analyze a sheet of paper, visualize hidden notes, and "lift" indented writings.[7]

This article will discuss one of the greatest advances in forensics: The use of DNA in criminal investigations.[8] This discovery has revolutionized crime solving and dramatically improved the operation of the criminal justice system.[9] The science is far from stagnant, and new DNA applications are regularly proposed.[10] This article will address familial DNA and forensic phenotyping, two of the latest and most controversial developments in crime solving techniques.[11]

A. THE BASICS OF DNA

The use of deoxyribonucleic acid (DNA) in forensics was discovered by accident in 1984, when Alec Jeffreys, a thirty-four-year-old British geneticist, compared blood samples from family members and concluded that a DNA profile could be created to distinguish the genetic makeup between individuals.[12] Jeffreys' study was undertaken to learn how inherited diseases are transmitted through families, but his research became the foundation for DNA fingerprinting.[13]

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5. *See* Willow Becker, *10 Modern Forensic Science Technologies*, FORENSIC COLLS., https://www.forensicscolleges.com/blog/resources/10-modern-forensic-science-technologies (last visited Nov. 10, 2018).
6. *See infra* text accompanying notes 25–28.
7. Becker, *supra* note 5.
8. *See* discussion *infra* Part D.
9. *What Are the Advantages of the Use of DNA in Criminal Cases?*, IN BRIEF, https://www.inbrief.co.uk/court-proceedings/dna-use-in-criminal-cases/ (last visited Nov. 10, 2018).
10. *See* Becker, *supra* note 5.
11. *See* discussion *infra* Sections C.1 and C.2.
12. Susan Matheson, *DNA Phenotyping: Snapshot of a Criminal*, 166 CELL 1061, 1061 (2016). The structure of DNA was first discovered in 1953, and it took thirteen years for scientists to figure out how DNA molecules code information. MING W. CHIN ET AL., FORENSIC DNA EVIDENCE AND THE LAW § 1:1, Westlaw (database updated May 2018).
13. Robin McKie, *Eureka Moment that Led to the Discovery of DNA Fingerprinting*, GUARDIAN (May 23, 2009, 7:01 PM), https://www.theguardian.com/science/2009/may/24/dna-fingerprinting-alec-jeffreys.

DNA provides the complete genetic code for a person[14] and contains the blueprint for building the proteins that are critical for our bodies to function.[15] The nucleus of every cell holds forty-six chromosomes assembled in pairs of twenty-two, plus two sex chromosomes—X for female and Y for male.[16] The structure of DNA looks like a double helix and resembles a twisted chain.[17] The sides of the chain are comprised of duplicate sequences of phosphate and deoxyribose sugar molecules.[18]

DNA is primarily found in the nucleus of cells and is thus dubbed nuclear DNA.[19] A small portion can also be detected in the mitochondria, where it is called mitochondrial DNA (mtDNA).[20] In turn, genetic material is saved in a coded sequence made up of four nitrogen elements: adenine (A), guanine (G), cytosine (C), and thymine (T).[21] Their sequencing controls the material accessible for constructing and preserving an organism, very much like the way that the letters of the alphabet are arranged to create words and sentences.[22] While each individual's genetic material is unique, most DNA coding is the same among humans.[23] In fact, it is estimated

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14. S. Panneerchelvam & M. Norazmi, *Forensic DNA Profiling and Database*, 10 MALAY. J. MED. SCI. 20, 20 (2005). The exception is red blood cells, which do not yield DNA results. *Id.*
15. Tim Newman, *What Is DNA and How Does It Work?*, MED. NEWS TODAY, https://www.medicalnewstoday.com/articles/319818.php (last updated Jan. 11, 2018).
16. Cobey v. State, 559 A.2d 391, 393 (Md. Ct. Spec. App. 1989).
17. George Smith & Janet Gordon, *The Admission of DNA Evidence in Federal and State Courts*, 65 FORDHAM L. REV. 2465, 2465–66 (1997).
18. *Id.* at 2466.
19. Diggs v. State, 73 A.3d 306, 318 (Md. Ct. Spec. App. 2013). Judge Kehoe points out that at one time, nuclear DNA was called the "human genome" and can usually be obtained from a specimen of blood, semen, saliva, body tissue, or hairs that have tissue at the end of the root. *Id.*
20. *What is DNA?*, GENETICS HOME REFERENCE, U.S. NAT'L LIBRARY OF MED., https://ghr.nlm.nih.gov/primer/basics/dna (last visited Nov. 10, 2018). Mitochondrial DNA is located inside an organelle suspended "in the cytoplasm surrounding the nucleus of a cell." Wagner v. State, 864 A.2d 1037, 1044–45 (Md. Ct. Spec. App. 2005). These organelles are called "mitochondrion" and are usually extracted from naturally shed hairs, hair fragments, bones, and teeth. *Diggs*, 73 A.3d at 317.
21. *Help Me Understand Genetics Cells and DNA*, GENETICS HOME REFERENCE, U.S. NAT'L LIBRARY OF MED., https://ghr.nlm.nih.gov/primer/basics/dna (last visited Nov. 10, 2018).
22. *Id.*
23. *DNA Profiling*, SCI. LEARNING HUB (Dec. 1, 2005), https://www.sciencelearn.org.nz/resources/1980-dna-profiling.

that 99.9% of our DNA is identical and only 0.1% of our sequences will vary; it is this small percentage that makes each person unique.[24]

DNA has been a vital part of forensic investigations[25] since the late 1980s and has helped solve thousands of crimes.[26] After all, DNA scientific data is considered more reliable than many other kinds of crime scene evidence,[27] and genetic identification is considered more accurate than fingerprint recognition.[28] A forensic analysis begins with obtaining a DNA sample from the crime scene or victim.[29] A small number of genetic markers are then identified by using manufactured chemical sequences, known as primers, which attach to similar DNA sequences of interest in the sample.[30] A string of primers joined to the DNA sample allow for enlargement of the original specimen so that a scientist can ascertain if a DNA profile exists.[31]

After a DNA sample is collected and forwarded to a laboratory for analysis, a profile is created by examining thirteen genetic markers dubbed "junk DNA," which are not associated with any identified genetic traits.[32] The facility then employs short tandem repeat (STR) technology, which is the repetitive progression of base pairs at all of the thirteen markers.[33] The disparity in the number of sequences at

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24. *How Does DNA Testing Work*, BBC SCI. (Feb. 1, 2013), http://www.bbc.co.uk/science/0/20205874. The DNA model of every person is made up of three billion base pairs, but only three million base pairs are different among people. Smith & Gordon, *supra* note 17, at 2466.
25. One of the major advantages of DNA use in criminal investigations is that it allows forensic typing of "samples invisible to the human eye." Walther Parson, *Age Estimation with DNA: From Forensic DNA Fingerprinting to Forensic (Epi)Genomics: A Mini-Review*, 4 GERONTOLOGY 326, 327 (2018).
26. *Forensic DNA*, NAT'L INST. OF JUSTICE, https://www.nij.gov/topics/forensics/evidence/dna/pages/welcome.aspx (last modified Apr. 10, 2018).
27. Karen Norrgard, *Forensics, DNA Fingerprinting, and CODIS*, NATURE EDUC. (2008), https://www.nature.com/scitable/topicpage/forensics-dna-fingerprinting-and-codis-736. A DNA specimen contains large quantities of personal and private data about that person, and, unlike a fingerprint, reveals information about the donor's health, tendencies for a disease, race and gender characteristics, and propensity for some forms of conduct. United States v. Kincade, 379 F.3d 813, 850 (9th Cir. 2004).
28. *See* Haskell v. Harris, 669 F.3d 1049, 1060 (9th Cir. 2012).
29. CHIN ET AL., *supra* note 12.
30. *Id.*
31. *Id.*
32. *Haskell*, 669 F.3d at 1051.
33. *DNA Evidence: Basics of Analyzing*, NAT'L INST. OF JUSTICE (Aug. 9, 2012), https://www.nij.gov/topics/forensics/evidence/dna/basics/pages/analyzing.aspx#sampleprocessing.

every marker establishes a distinctive profile[34] that may be used for identification purposes.[35] For instance, "[o]ne person might have two copies of the first marker that are four and eight repeats long, copies of the second that are eleven and twenty-three copies long, copies of the third that are three and ten copies long, and so on through all thirteen markers."[36] The chance that two individuals will have identical sequences on all thirteen markers are astronomically small.[37]

Next, the sample is compared to the many other DNA profiles contained in international, federal, and state databanks.[38] If the suspect's DNA does not match the specimen taken from the victim or crime scene, that person may be eliminated from the suspect list.[39]

B. DNA FINGERPRINTING

DNA fingerprinting allows criminalists to take blood, saliva, or skin cells found at a crime scene and create a DNA profile to compare with samples contained in a database,[40] such as CODIS.[41] As noted in *Haskell v. Harris*, DNA fingerprinting has the advantage of exculpating individuals who are imprisoned for offenses they did not commit and eliminating individuals from suspect lists when

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34. A DNA profile is the genetic constitution of an individual at defined locations in the DNA, and it is obtained from nuclear DNA that usually involves one or two alleles at several loci, known as short tandem repeat loci. Matheson, *supra* note 12; *see* Diggs v. State, 73 A.3d 306, 328 (Md. Ct. Spec. App. 2013).
35. *Haskell*, 669 F.3d at 1051.
36. United States v. Mitchell, 652 F.3d 387, 401 (3d Cir. 2011) (en banc).
37. *Haskell*, 669 F.3d at 1051–52.
38. *Id.*
39. *Id.*
40. Norrgard, *supra* note 27; *Diggs*, 73 A.3d at 319–20. The first national database was established in England in 1995, and the second was created in Austria in 1997. Parson, *supra* note 25, at 328.
41. CODIS stands for the Combined DNA Index System, and it is the moniker used to describe the FBI's DNA databases and the software employed to run them. *Frequently Asked Questions on CODIS and NDIS*, FED. BUREAU OF INVESTIGATION, https://www.fbi.gov/services/laboratory/biometric-analysis/codis/codis-and-ndis-fact-sheet (last visited Nov. 10, 2018). A subpart of CODIS is the National DNA Index System (NDIS) which contains the DNA profiles submitted by federal, state, and local laboratories. *Id.* The sample is generally taken from the offender's blood and forwarded to the Federal DNA Database Unit (FDDU) in Quantico, Virginia, where the DNA molecules from each blood sample are extracted and analyzed. *Id.* A profile is then created, identifying characteristics, and uploaded to CODIS. *Id.* Not only is this profile stored in CODIS, but the Federal DNA Database Unit also keeps the blood sample to help guarantee correct matches to DNA found at crime scenes. United States v. Kriesel, 720 F.3d 1137, 1140 (9th Cir. 2013).

crimes occur.[42] Historically, state law limited the collection and storage of DNA to those convicted of murder and rape because of the severity of these crimes and the likelihood that DNA evidence would be left behind at these crime scenes.[43] This limitation did not last long with the enactment of legislation allowing for the collection of DNA in most criminal matters.[44] At the present time, all states and the federal government use CODIS for the storage of DNA profiles,[45] which allows crime labs around the country to share and compare genetic materials.[46] As of June 2018, this national database contained over 13,413,029 offender profiles, 3,174,013 arrestee profiles, and 864,128 forensic profiles.[47]

DNA fingerprinting[48] is extremely reliable, therefore law enforcement officials frequently collect genetic material when a

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42. *Haskell*, 669 F.3d at 1064 (quoting United States v. Sczubelek, 402 F.3d 175, 185 (3d Cir. 2005)).
43. Mark A. Rothstein, *Privacy and Technology in the Twenty-First Century*, 52 U. LOUISVILLE L. REV. 333, 340 (2014).
44. SARA DEBUS-SHERRILL & MICHAEL FIELD, UNDERSTANDING FAMILIAL DNA SEARCHING: POLICIES, PROCEDURES, AND POTENTIAL IMPACT 2 (2017).
45. *Id.* CODIS was created following the passage of the Violent Crime Control and Law Enforcement Act of 1994, which authorized the FBI to establish a national database for DNA samples collected from convicted federal offenders. *See* Pub. L. No. 103-322, 108 Stat. 1796 (1994); *Kriesel*, 720 F.3d at 1140.
46. DEBUS-SHERRILL & FIELD, *supra* note 44, at 2–3. CODIS is segregated into different subparts such as the Convicted Offender Index, Arrestee Index, Forensic Index, indices for unidentified human remains and samples obtained from the family of missing persons. *Id.* at 3. The FBI restricts the material kept in CODIS. United States v. Mitchell, 652 F.3d 387, 400 (3d Cir. 2011). For instance, no names or other personal identifiers of the offenders, arrestees, or detainees are recorded. *Id.* Rather, the database lists only:

> (1) the DNA profile; (2) a number identifying the agency that submitted the DNA profile. . . (3) a 'Specimen Identification Number' which the FBI states is 'generally a number assigned sequentially at the time of sample collection' and 'does not correspond to the individual's social security number, criminal history identifier, or correctional facility identifier;' and (4) information identifying the laboratory personnel associated with creating the profile.

Id. (quoting Frequently Asked Questions on CODIS and NDIS, supra note 41).

47. *CODIS - NDIS Statistics*, FED. BUREAU OF INVESTIGATION, https://www.fbi.gov/services/laboratory/biometric-analysis/codis/ndis-statistics (last visited Nov. 10, 2018).
48. One of the first successful uses of DNA fingerprint occurred in 1987 when a DNA sample was used to help solve the killing of two girls. Parson, *supra* note 25, at 327. The investigators matched the semen found on both victims with the criminal. *Id.* Two factors stand out concerning this famous case: The person who was initially

person is implicated in a crime.[49] The major limitation on the test's effectiveness is the quality of the sample.[50] A poor specimen can cause unclear results compelling significant interpretation by the forensic expert, which can potentially cause rare interpretation mistakes or differing opinions about the results.[51] Because each person's genetic material is unique, it is compared against the crime scene evidence and stored in a database for comparison with materials from past and future crimes.[52] As a consequence, this genetic information has altered the work of those involved in the criminal law system and become an integral part of formulating a legal defense.[53]

DNA profiling initially developed as a means to establish paternity.[54] It made its way into a criminal court in 1986, when a molecular biologist used DNA to disaffirm the confession of a young man accused of two murders in central England.[55] The scientist demonstrated that the teenager under investigation was not the criminal, and the real culprit was subsequently apprehended, also through the use of DNA testing.[56] One year later, a Florida court was asked to determine the admissibility of "genetic fingerprint" evidence in order to identify the perpetrator of a sexual battery.[57] In *Andrews v. State*, the government presented DNA evidence linking the defendant to a rape through genetic material found in a vaginal swab taken from the victim.[58] The government's expert testified that the DNA matched the defendant's genetic profile and explained that the

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suspected of committing the crimes was exonerated based upon the DNA, and law enforcement screened more than 5,000 men in order to find the offender. *Id.*

49. *See* Norrgard, *supra* note 27.
50. 8 AM. JUR. 3D *Proof of Facts* § 749 (1990). A DNA sample is only useful in solving a crime if the genetic material of the offender is available for comparison. Parson, *supra* note 25, at 328.
51. AUSTRALIAN GOV'T: AUSTRALIAN LAW REFORM COMM'N, ESSENTIALLY YOURS: THE PROTECTION OF HUMAN GENETIC INFORMATION IN AUSTRALIA 1092 (2003), http://www.alrc.gov.au/sites/default/files/pdfs/publications/ALRC96_vol2.pdf.
52. Norrgard, *supra* note 27.
53. CHIN ET AL., *supra* note 12.
54. Lisa Calandro et al., *Evolution of DNA Evidence for Crime Solving - A Judicial and Legislative History*, FORENSIC MAG. (Jan. 6, 2005, 3:00 AM), https://www.forensicmag.com/article/2005/01/evolution-dna-evidence-crime-solving-judicial-and-legislative-history.
55. *Id.*
56. *Id.*
57. Andrews v. State, 533 So. 2d 841, 842 (Fla. Dist. Ct. App. 1988), *abrogated by* Hadden v. State, 690 So. 2d 573 (Fla. 1997).
58. *Id.* at 842–43.

chance someone else's DNA matched the suspect's was 1 in 839,914,540.[59]

DNA is routinely accepted in court as an independent "science-based identification method"[60] to establish a person's guilt,[61] exonerate someone wrongfully convicted of a crime,[62] or establish paternity.[63]

Many countries are gathering and storing genetic materials in databases with the proffered reason of fighting crime and combating terrorism.[64] In fact, the United States Supreme Court in *Maryland v. King* gave the police the power to routinely collect DNA from a person arrested, but not yet convicted of a serious offense, and to enter that person's DNA profile into its databases.[65] The facts of *King* reveal that a man who had concealed his face broke into a woman's home and raped her.[66] No one could identify the assailant, but the investigator secured a sample of the criminal's DNA from the victim.[67] Six years later, King was arrested for threatening a group of people with a gun.[68] During his processing, a DNA sample was obtained through a buccal swab from his mouth and found to match the DNA from the earlier rape case.[69] King was indicted for the rape but moved to suppress the DNA evidence as a violation of his Fourth Amendment rights.[70] Maryland law at the time allowed the police to secure DNA samples from "persons charged with violent crimes, including first-degree assault."[71] The Supreme Court upheld this practice noting that it is an essential advance in the methods long

59. *Id.* at 843. The first case in which the defense mounted a vigorous challenge to DNA evidence occurred in 1989. *See* People v. Castro, 545 N.Y.S.2d 985 (1989).

60. CHIN ET AL., *supra* note 12.

61. *See* Commonwealth v. Crews, 640 A.2d 395 (Pa. 1994). In fact, in some jurisdictions, DNA results are automatically admissible to prove or disprove the identity of an individual as long as certain conditions are satisfied. Phillips v. State, 152 A.3d 712, 714–15 (Md. 2017).

62. Statistics compiled as of January 2018 reveal that more than 350 persons wrongfully convicted of a crime, of which twenty were on death row, have been freed based upon DNA evidence. CHIN ET AL., *supra* note 12.

63. Norrgard, *supra* note 27.

64. Jill Lawless, *Is Your DNA in a Police Database?*, NBC News (Nov. 2, 2015, 6:27 PM), https://www.nbcnews.com/news/world/your-dna-police-database-flna6C10617124.

65. Maryland v. King, 569 U.S. 435, 465–66 (2013).

66. *Id.* at 439–40.

67. *Id.* at 440.

68. *Id.*

69. *Id.*

70. *Id.* at 441.

71. *Id.* at 435.

used by law enforcement officials to serve legitimate police concerns.[72]

This decision was not the last word on the topic. The collection of DNA from those arrested may violate a state's constitution, and a 2018 California case offers such an example.[73] California voters approved the DNA Fingerprint, Unsolved Crime and Innocence Act, which allows police to collect DNA samples from individuals arrested for felony offenses.[74] In *People v. Buza*, a defendant was arrested for arson and transported to jail where he was then asked to provide a DNA sample.[75] He declined and was convicted of a separate offense for refusing to provide DNA material, which *King* had previously established violated a variety of federal and state constitutional provisions.[76]

The California Supreme Court acknowledged that state and federal governments mandate the collection of DNA from those convicted of felony offenses, and a number of jurisdictions permit the collection of DNA from those merely arrested for felony offenses.[77] This practice is traditionally premised upon five governmental interests: 1) the value of the knowledge of who has been arrested and who is currently being tried after arrest; 2) the importance of DNA data to law enforcement, which allows officers to strategize how to proceed in an investigation; 3) the substantial interest the state has in ensuring an accused will be available for and appear at trial; 4) the significance of the ability to be aware of an offender's past conduct, and thus, the state's ability to protect public safety (which often affects whether an offender is released on bail); and 5) the beneficial value of DNA identifying and freeing wrongfully accused individuals.[78]

The result in the instant case turned on whether requiring a person to provide a DNA sample as part of a routine booking procedure following an arrest violated California's state constitution.[79] The dissent found that it did and noted that:

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72. *Id.* at 456.
73. People v. Buza, 413 P.3d 1132, 1178 (Cal. 2018).
74. Proposition 69 was approved by the voters in a general election on November 2, 2004. *Buza*, 413 P.3d at 1135. *See also* CAL. PENAL CODE § 296.1(a)(1)(A) (West 2012).
75. *Buza*, 413 P.3d at 1135.
76. *Id.*
77. *Id.* at 1139 (citing Maryland v. King, 569 U.S. 435, 445 (2013)).
78. *Id.* at 1140 (quoting *King*, 569 U.S. at 450–55).
79. *Id.* at 1153.

> [The DNA Fingerprint, Unsolved Crime and Innocence Act's] requirements constitute a major intrusion into the privacy of all the people subject to its procedures. Focusing solely on the physical collection of DNA samples understates the invasion at issue in this case. The DNA Act is unusual in that it effects more than one intrusion into a person's privacy and autonomy: the intrusion occurs not only when the arrestee is physically subjected to the DNA collection, but also when his biological sample is processed to create a DNA profile, stored indefinitely in federal and state databases, and potentially analyzed in the future when conducting comparisons against newly obtained samples. This continuing intrusion makes the . . . Act's search unlike other ordinary searches and seizures, as the potential infringement on an individual's privacy is ongoing.[80]

It should be noted that the potential locations for finding DNA at a crime scene are endless, so members of law enforcement are continually educated about new approaches involving evidence collection and DNA preservation.[81] At one time, crime scene evidence was kept in a plastic bag, but current methods favor securing dried samples in paper bags to avoid contamination or degradation from moisture.[82] Advances have also reduced the amount of saliva, blood or hairs needed to obtain a viable DNA sample, and nationwide protocols in handling and testing are ensuring the admissibility of test results in court.[83]

C. CURRENT CONTROVERSIES

The use of DNA in forensics has a proven track record that has assisted both the prosecution and defense, but it is not without controversy.[84] It is expected that experts will occasionally disagree about the analysis and statistical meaning of test results.[85] However, as new forensic applications are discovered, some raise difficult

80. *Id.* at 1173 (Cuéllar, J., dissenting).
81. *See DNA Fingerprinting (Police)*, WHAT–WHEN–HOW, http://what-when-how.com/police-science/dna-fingerprinting-police/ (last visited Nov. 10, 2018).
82. *Id.*
83. *See id.*
84. *See generally* William C. Thompson, Laurence D. Mueller & Dan E. Krane, *Forensic DNA Statistics: Still Controversial in Some Cases*, CHAMPION, Dec. 2012, at 12 (discussing controversies surrounding DNA statistics).
85. *See id.*

ethical and legal issues.[86] Two of the most controversial new applications are familial DNA and forensic phenotyping.[87]

1. Familial DNA

The government has arrested more than 250 million people during the past few decades.[88] It is, therefore, not surprising that the FBI has a list of 77.7 million people in its criminal databases.[89] Statistically, this means that federal authorities have information stored on approximately one out of every three adults.[90] Nevertheless, some advocate that DNA samples should be obtained from every person, and DNA testing continues to expand with very few objections because of the unsupported assumption that more DNA testing reduces crime.[91]

There are still times when there is no match found to link DNA from a crime scene or victim with the DNA profiles in criminal databases.[92] In these situations, several countries perform familial DNA searching (FDS).[93] This controversial technique is defined as a "deliberate search of a DNA database conducted for the intended purpose of potentially identifying close biological relatives to the unknown forensic profile obtained from crime scene evidence."[94]

The United Kingdom was the first nation to search for familial DNA matches and prosecute the person apprehended.[95] The British police primarily use this technique to solve cold cases and are aided by very sophisticated databases.[96] For instance, they identified a serial killer from the 1970s after examining DNA from the crime

86. Caio Cesar Silva de Cerqueira et al., *Predicting Physical Features and Diseases by DNA Analysis: Current Advances and Future Challenges*, 7 J. FORENSIC RES. 1, 6 (2016).
87. *See* discussion *infra* Sections C.1 and C.2.
88. Gary Fields & John R. Emshwiller, *As Arrest Records Rise, Americans Find Consequences Can Last a Lifetime*, WALL ST. J. (Aug. 18, 2014, 10:30 PM), https://www.wsj.com/articles/as-arrest-records-rise-americans-find-consequences-can-last-a-lifetime-1408415402.
89. *Id.*
90. *Id.*
91. Rothstein, *supra* note 43, at 341.
92. *See infra* notes 102–04 and accompanying text.
93. DEBUS-SHERRILL & FIELD, *supra* note 44, at 1, 4–5.
94. Allison Murray et al., *Familial DNA Testing Current Practices and Recommendations for Implementation*, 9 INVEST. SCI. J. 1, 2 (2017), http://www.investigativesciencesjournal.org/article/download/17782/11554.
95. DEBUS-SHERRILL & FIELD, *supra* note 44, at 4–5.
96. *See* Murray et al., *supra* note 94.

scene, which revealed a familial link to the killer's son, who had been convicted of car theft.[97] The United States is slowly embracing the practice, and at least twelve states allow familial DNA searching.[98]

FDS is performed by law enforcement officials who search their databanks for genetic information linked to a relative of an individual they are attempting to identify.[99] These searches may locate a partial match, such as ten of the twenty critical DNA markers,[100] with the crime scene evidence thereby pointing to a child, parent, or other blood relative of the culprit. For instance, if the suspect's brother has been arrested, and his DNA is contained in the computer system, a familial DNA search may put the police in contact with the sibling, and in turn, the suspect.[101]

FDS generated a fair amount of publicity when it was used to solve the Grim Sleeper case in 2016.[102] This criminal caused havoc in the Sacramento, California area for six years as he continued to sexually assault women.[103] Despite possessing the perpetrator's DNA samples from several different crime scenes, law enforcement officials were unable to make a positive identification because the samples did not match any DNA maintained in a database of convicted felons.[104] Eventually, the police conducted a search for a

97. Jessica McBride, *Familial DNA Searches: 5 Fast Facts You Need to Know*, HEAVY (Dec. 8, 2016, 10:54 PM), https://heavy.com/news/2016/12/familial-dna-searches-search-karina-vetrano-new-york-queens-father-analysis-testing-test-current-approaches-justin-christian-ohio/. One reason for the United Kingdom's success is due to its DNA database, which is the largest per capita DNA database in the world. Murray et al., *supra* note 94.

98. James Rainey, *Familial DNA Puts Elusive Killer Behind Bars. But Only 12 States Use It.*, NBC NEWS (Apr. 28, 2016, 6:00 AM), https://www.nbcnews.com/news/us-news/familial-dna-puts-elusive-killers-behind-bars-only-12-states-n869711.

99. *Familial DNA Searches*, FINDLAW, https://criminal.findlaw.com/criminal-rights/familial-dna-searches.html (last visited Nov. 10, 2018).

100. *See Prosecutors Used Genealogy Website to Track Down Golden State Killer*, YAHOO! (Apr. 27, 2018), https://www.yahoo.com/news/prosecutors-used-genealogy-website-track-160300648.html.

101. *Familial DNA Searches*, *supra* note 99. The makeup of DNA renders it easy to determine a person's sex. Bert-Japp Koops & Maurice Schellekens, *Forensic DNA Phenotyping: Regulatory Issues*, 9 COLUM. SCI. & TECH. L. REV. 158, 161 (2008). Females have two X chromosomes as compared to their male counterparts who have an X and Y chromosome. *Id.* Therefore, if a Y chromosome appears in the DNA sample, the person is male. *Id.*

102. *See* Marisa Gerber, *The Controversial DNA Search that Helped Nab the 'Grim Sleeper' Is Winning Over Skeptics*, L.A. TIMES (Oct. 25, 2016, 3:00 AM), http://www.latimes.com/local/lanow/la-me-familial-dna-20161023-snap-story.html.

103. *Id.*

104. *Id.*

partial, familial match.[105] A partial match was made to DNA from the suspect's jailed brother, and the Grim Sleeper was subsequently apprehended.[106]

While familial DNA searches are a potentially useful tool for law enforcement agencies, the results from such searches do not always provide accurate leads, as was demonstrated by Michael Usry, a filmmaker from New Orleans, who attracted the attention of the Idaho Falls Police Department in connection with a murder due to the violent nature of his films.[107] The police suspected Usry of murdering a woman in a 1996 case that had gained national attention because it was alleged that the wrong person had been convicted.[108] The central issue in the case was the lack of a DNA match from the crime scene to anyone in the national criminal databases.[109]

A familial DNA search in a publicly accessible database subsequently found a partial match with Usry's father, which indicated that one of the father's relatives was responsible for the crime.[110] Years prior to the match, the elder Usry had donated a DNA sample through his church to a nonprofit foundation whose forensic assets had been acquired by *Ancestry.com*.[111] The court ordered *Ancestry.com* to conduct a genetic search of its files, and the police narrowed their inquiry to three men in the father's family tree.[112] The application for a search warrant for the filmmaker's DNA listed Usry's ties to Idaho and noted the violent nature of some of his short films as justification for his status as a suspect in the murder.[113] Following the grant of the search warrant, Usry was interrogated by federal agents and his DNA was collected; a month later, he learned that his DNA did not match the evidence collected at the crime scene, but his unsettling experience focused attention on the delicate balance between an individual's right to privacy and public safety.[114]

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105. *Id.*
106. *Id.*
107. Jim Mustian, *New Orleans Filmmaker Cleared in Cold-Case Murder; False Positive Highlights Limitations of Familial DNA Searching*, NEW ORLEANS ADVOC. (Mar. 12, 2015, 7:20 AM), https://www.theadvocate.com/new_orleans/news/article_1b3a3f96-d574-59e0-9c6a-c3c7c0d2f166.html.
108. *Id.*
109. *Id.*
110. *Id.*
111. *Id.*
112. *Id.*
113. *Id.*
114. *Id.*

Supporters of familial DNA searches maintain that it is an innocuous method of producing leads for the police hoping to solve cold cases.[115] After all, a partial DNA match of crime scene DNA evidence to existing genetic profiles in DNA databases can lead police to family members of possible suspects.[116] Proponents further assert that the practice could increase the number of identified suspects by 40%, thereby helping police solve more crimes.[117]

Critics counter that the technique violates the Fourth Amendment guarantee against unreasonable searches and seizures because the practice uses the DNA of innocent family members.[118] There is also concern that the practice will result in subjecting a disparate number of Hispanics and African-Americans to such searches, as these minorities have historically been incarcerated at disproportionately higher rates than other racial groups.[119] For instance, one study demonstrated that while the overall rate of false identification is small, African-Americans have twice the chance of being incorrectly targeted for further investigation.[120] The higher probability of being incorrectly targeted will lead to far more African-Americans suffering disproportionately from intrusions of privacy and police interrogations.[121]

Familial DNA searches have little legislative regulation,[122] and there are no standards on a national level to provide guidance on how states should proceed in developing policies for these searches.[123] Most regulatory measures are done at an agency level.[124] Privacy concerns represent a common theme arising from the requirements of those states that allow the practice.[125] Most of these jurisdictions

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115. *See, e.g.*, Eli Rosenberg, *Family DNA Searches Seen as Crime-Solving Tool, and Intrusion on Rights*, N.Y. TIMES (Jan. 27, 2017), https://www.nytimes.com/2017/01/27/nyregion/familial-dna-searching-karina-vetrano.html.
116. *See* Gerber, *supra* note 102.
117. *States Turning to New "Familial DNA" Tests, Practice Faces Legal Hurdles*, HOMELAND SEC. NEWS WIRE (May 17, 2011), http://www.homelandsecuritynewswire.com/states-turning-new-familial-dna-tests-practice-faces-legal-hurdles; Rainey, *supra* note 98.
118. *States Turning to New "Familial DNA" Tests, Practice Faces Legal Hurdles*, *supra* note 117.
119. *Id.*
120. RORI V. ROHLFS ET AL., THE INFLUENCE OF RELATIVES ON THE EFFICIENCY AND ERROR RATE OF FAMILIAL SEARCHING, PLOS ONE 4 (Thomas Mailund ed., 2013).
121. Lauren Kirchner, *The Flaws of Familial DNA Matching*, PAC. STANDARD (Aug. 20, 2013) https://psmag.com/enviroment/the-flaws-of-familial-dna-matching-64736.
122. DEBUS-SHERRILL & FIELD, *supra* note 44, at 9.
123. Murray et al., *supra* note 94, at 2.
124. DEBUS-SHERRILL & FIELD, *supra* note 44, at 9.
125. *Id.* at 5, 14–15.

restrict the number or types of searches that may be performed.[126] For example, a jurisdiction may limit searches to cold cases or to matters that have an impact on public safety such as major crimes of violence.[127] Further, these jurisdictions expressly enumerate the scope of familial searches in their policies and procedures.[128]

In 2008, California was the first state to regulate familial DNA searches.[129] California's comprehensive policy provides that searches may only be requested as a "last resort" when all other investigative methods have been explored,[130] and the matter involves a major crime of violence.[131] Colorado,[132] Wisconsin,[133] Virginia,[134] Michigan,[135] Texas,[136] Wyoming,[137] Utah,[138] and Florida[139] have followed suit by creating protocols for these searches.[140] Since 2012, Ohio has also authorized familial DNA searches, but it has created a 12-page protocol that must be followed.[141] New York's legislature was unable to enact a law on the topic, but in June 2017, the State Commission on Forensic Science approved FDS use in unsolved

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126. Murray et al., *supra* note 94, at 3.
127. *Id.*
128. *Id.*
129. Gerber, *supra* note 102.
130. *Id.*
131. *Familial DNA Searches*, *supra* note 99.
132. *See States Using Familial Searches*, DNA FORENSICS, http://www.dnaforensics.com/StatesAndFamilialSearches.aspx (last visited Nov. 10, 2018) ("A familial search software program was designed by the DA's office and Denver Police Crime Lab. The program would only extend to siblings and parents. When a hit is made, family members could not be questioned unless investigators isolate a suspect using traditional detective work.").
133. Seth Augenstein, *Familial Searching, Used in 10 States and Counting, Solves the Unsolvable*, FORENSIC MAG. (Dec. 8, 2016, 12:55 PM), https://www.forensicmag.com/news/2016/12/familial-searching-used-10-states-and-counting-solves-unsolvable.
134. Virginia allows familial DNA searches in cold cases and violent crimes that remain open as long as all other investigative methods have been utilized. *Virginia Enacts Familial DNA Testing Law*, INNOCENCE PROJECT (Mar. 24, 2011), https://www.innocenceproject.org/virginia-enacts-familial-dna-testing-law/.
135. Augenstein, *supra* note 133.
136. *Id.*
137. *Id.*
138. *Id.*
139. The DNA Lab in Florida is allowed to provide investigators with the names of convicted offenders who match a crime scene sample by at least 21 of 26 alleles. *States Using Familial Searches*, *supra* note 132. This number typically belongs to brothers. *Id.*
140. Gerber, *supra* note 102.
141. McBride, *supra* note 97.

cases that present a public safety threat, such as murders, rapes, and arsons.[142] According to very strict requirements, all search requests must be endorsed by the state police, Division of Criminal Justice Services, District Attorney, and local law enforcement.[143] Next, the results must be reviewed by the forensic center of the state police before they may be given to the initiating police department.[144] The Federal Bureau of Investigation prohibits accessing its National DNA Index System database to search for familial matches,[145] and Maryland has banned the practice altogether.[146]

2. DNA Phenotyping

Eyewitness identification has always been a part of a criminal investigation, and witness observations are premised upon their physical awareness of the crime.[147] The description, however, cannot be based upon hearsay.[148] For instance, identification can be premised upon a photographic array or lineup, but not what someone else told the person.[149] Witnesses also work with the police to produce a composite sketch of the assailant, which is made by an artist or mechanized composite production system.[150] Unfortunately, these methods have resulted in a number of people being wrongfully convicted.[151] Drawings offer poor representations of the suspect's features, even when a face is familiar to the witness.[152] This is likely attributable to a mismatch in the way individuals encode faces and recall profiles when creating a composite.[153] Eyewitness identification is often unreliable because visibility conditions may not

142. Nathan Tempey, *State Panel Approves Police Use of Controversial Familial DNA Records Searches*, GOTHAMIST (June 16, 2017, 4:25 PM), http://gothamist.com/2017/06/16/familial_dna_testing_ny_state.php.
143. *Id.*
144. *Id.*
145. DEBUS-SHERRILL & FIELD, *supra* note 44, at 4.
146. *States Using Familial Searches*, *supra* note 132.
147. *See* Jessica Tran, *What Is Eyewitness Identification?*, LEGAL MATCH, https://www.legalmatch.com/law-library/article/eyewitnessidentification.html (last modified May 18, 2018).
148. *Id.*
149. *Id*.
150. *Facial Composites*, CRIMINAL JUSTICE, http://criminal-justice.iresearchnet.com/forensic-psychology/facial-composites/ (last visited Nov. 10, 2018).
151. *Eyewitness Identification*, NAT'L INST. OF JUSTICE, https://www.nij.gov/topics/law-enforcement/investigations/eyewitness-identification/Pages/welcome.aspx (last modified Mar. 16, 2018).
152. *Facial Composites*, *supra* note 150.
153. *Id.*

be ideal, people have poor facial identification skills, and the methods of identification may be biased.[154]

Investigations usually end up in a pile of cold case files when traditional forensic tools fail to identify a suspect.[155] Recent DNA advancements, however, offer promise in these situations by creating a digital mug shot based upon human genetics.[156] This process, known as DNA phenotyping or molecular protofitting, offers great promise by predicting a suspect's physical characteristics such as sex, hair color, and ancestry based upon DNA left at a crime scene.[157] By determining how genetic DNA converts into physical appearance, the marketers of this technique maintain that it is feasible to "reverse-engineer" DNA into a physical profile.[158] This is accomplished by analyzing thousands of genetic variants, known as genotypes, from the specimen in order to predict the appearance of the assailant.[159] It is said that the phenotype prediction has an accuracy rate equal to or greater than 90%.[160]

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154. Marc Green, *Errors in Eyewitness Identification Procedures*, VISUAL EXPERT, http://www.visualexpert.com/Resources/mistakenid.html (last visited Nov. 10, 2018).

155. *What Is a Cold Case?*, NAT'L INST. OF JUSTICE (July 15, 2008), https://nij.gov/journals/260/pages/what-is-cold-case.aspx.

156. Clive Cookson, *DNA: The Next Frontier in Forensics*, FIN. TIMES (Jan. 30, 2015), https://www.ft.com/content/012b2b9c-a742-11e4-8a71-00144feab7de.

157. *Id.* (outlining the forensic phenotyping work primarily conducted by a small cadre of researchers, including Manfred Kayser, Tim Spector, and Susan Walsh); Michelle Van Laan, *The Genetic Witness: Forensic DNA Phenotyping*, 2 J. OF EMERGING FORENSIC SCI. RES. 33, 36 (2017), https://jefsr.uwindsor.ca/index.php/jefsr/issue/view/478/71.

158. *The Snapshot DNA Phenotyping Service*, PARABON NANOLABS, https://snapshot.parabon-nanolabs.com/#phenotyping (last visited Nov. 10, 2018) (also noting that heritable traits, such as eye color, are more easily predictable than those that are impacted by environmental factors, such as body mass).

159. *Id.*

160. *Frequently Asked Questions (FAQs) About Snapshot*, PARABON NANOLABS, https://snapshot.parabon-nanolabs.com/faq (last visited Nov. 10, 2018). *See generally How DNA Phenotyping Works*, PARABON NANOLABS, https://snapshot.parabon-nanolabs.com/phenotyping (last visited Nov. 10, 2018).

> Whereas traditional DNA forensics matches STRs [short tandem repeats] from a sample to a known suspect or a database, DNA phenotyping can generate new leads about an individual, even if they have not previously been identified in a database. DNA phenotyping takes advantage of modern SNP [single nucleotide polymorphism] technology to read the parts of the genome that actually code for the differences between people. The Snapshot DNA Phenotyping System translates SNP information from an unknown individual's DNA sample into predictions of ancestry

Phenotype is derived from the Greek words *phainein*, meaning "to show" and *typos*, meaning to "type."[161] Phenotyping is the ability to present a composite of an organism's observable characteristics or traits.[162] Forensic phenotyping, therefore, predicts the physical appearance of an unknown person from their DNA.[163] The science is premised upon the principle that DNA possesses the key to our physical make-up and produces a biological blueprint that can predict "physical feature developmental propensities."[164] As geneticist Richard Spritz stated, phenotyping is "what your grandmother is responding to when she says you look like your father."[165]

Forensic phenotyping is different from DNA profiling, which applies DNA as a biometric identifier to match a person's genetic material with evidence recovered at the crime scene.[166] DNA phenotyping, on the other hand, allows the criminalist to reduce the suspect pool by examining a person's ancestry and appearance when there is no DNA match in a database such as CODIS.[167]

The first application of DNA phenotyping occurred in the Netherlands in 1999 as a result of the rape and murder of a 16-year-old girl.[168] The investigation was not making any progress, and much unrest had developed surrounding the issue of asylum seekers from Iraq and Afghanistan living in the area.[169] Dutch law at the time prohibited using DNA analysis to predict a person's ancestry and genetic characteristics, but this did not stop a forensic

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> and physical appearance traits, such as skin color, hair color, eye color, freckling, and even face morphology.

Id.

161. *Phenotype*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/phenotype (last updated Sept. 19, 2018).
162. *See id.*
163. Kathy Marks, *DNA Phenotyping Shows Results*, POLICE & SEC. NEWS (July 26, 2017), https://policeandsecuritynews.com/2017/07/26/dna-phenotyping-shows-results/.
164. Van Laan, *supra* note 157, at 22.
165. Jim Dawson, *Defining a Face: What Can DNA Phenotyping Really Tell Us About an Unknown Sample?*, NAT'L INST. OF JUSTICE (Sept. 25, 2015), https://www.nij.gov/topics/forensics/evidence/dna/Pages/dna-phenotyping.aspx.
166. *How This Technique Differs from Familial Searches in CODIS*, PARABON NANOLABS, https://snapshot.parabon-nanolabs.com/phenotyping (last visited Nov. 10, 2018).
167. *How DNA Phenotyping Works*, *supra* note 160.
168. Sascha Karberg, *Phenotyping: The Hidden Mugshot in a Culprit's DNA*, EUR. BIOTECHNOLOGY, https://european-biotechnology.com/up-to-date/backgrounds-stories/story/phenotyping-the-hidden-mugshot-in-a-culprits-dna.html?L=0&cHash=8e2545661940dc8c06ba110b15d1e940 (last visited Nov. 10, 2018). Predicting phenotypes is not new and has been used in the medical field for years to predict genetic diseases in a person. Silva de Cerqueira et al., *supra* note 86, at 1.
169. Karberg, *supra* note 168.

investigator who examined the DNA found at the crime scene, with the help of the local police, for the purpose of identifying the assailant's biogeographical ancestry.[170] This analysis became known as a proverbial 'shot heard around the world' because this case opened the door to new avenues of investigation—filled with ethical and legal challenges.[171]

Twelve years later, a twenty-five-year-old woman and her young daughter were murdered in their South Carolina home.[172] On the fourth anniversary of the unsolved crime, the Columbia police issued a digital image of the suspect based on a DNA sample found at the crime scene.[173] This is believed to be the first time that forensic phenotyping was used in the United States to create such a picture.[174]

One hundred and fifty of the 200 people interviewed by police in this case submitted DNA samples, but none of the samples matched the DNA collected at the crime scene.[175] The investigator had heard about the new genetic technique and contacted Parabon Zanolabs, a Virginia-based firm supported by the U.S. Department of Defense, which specialized in the process.[176] The police spent approximately $4,000 to have the sample analyzed,[177] and DNA phenotyping determined that the suspect was 92% West African and 8% European with black or brown eyes and freckles.[178] A computer-generated wanted poster was then created depicting the suspect.[179] Since this initial use, police departments in California, Colorado, Florida, Louisiana, Massachusetts, North Carolina, Ohio, Rhode Island,

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170. *Id.*
171. *Id.*
172. Sean Allocca, *First DNA-Phenotyped Image of 'Person of Interest' in Double Homicide*, FORENSIC MAG. (Jan. 15, 2015, 2:50 PM), https://www.forensicmag.com/article/2015/01/first-dna-phenotyped-image-person-interest-double-homicide.
173. Cookson, *supra* note 156.
174. *Id.*
175. Howard Wolinsky, *CSI on Steroids*, 16 EMBO REPS. 782, 782 (2015), http://embor.embopress.org/content/embor/16/7/782.full.pdf.
176. *Id.* There are currently three main entities involved with forensic phenotyping: Illumina, Identitas, and Parabon NanoLabs. *See* Van Laan, *supra* note 157, at 37. Parabon markets a tool dubbed "Parabon Snapshot" that is capable of providing genetic geology, DNA phenotyping, and kinship inferences. *Parabon Snapshot*, PARABON NANOLABS, https://snapshot.parabon-nanolabs.com/ (last visited Nov. 10, 2018). It is advertised that "Snapshot is ideal for generating investigative leads, narrowing suspect lists, and solving human remains cases, without wasting time and money chasing false leads." *Id.*
177. Wolinsky, *supra* note 175, at 782.
178. *Id.*
179. *Id.*

Texas, Utah, Virginia, and Washington have each utilized this genetic tool.[180]

There are two types of forensic phenotyping: indirect and direct.[181] Indirect deals with a person's external characteristics, which are determined by the individual's geographic or ethnic origin.[182] This is similar to the information provided by a DNA search performed by *23 and Me* or *Ancestry.com*.[183] Direct phenotyping can disclose external characteristics such as eye and hair color, hair shape, skin color, height, age, and shape of the skull.[184] It may even be possible to forecast whether a person has the propensity to smoke, stutter, or is left-handed.[185]

Forensic phenotyping has the advantage of creating investigative leads, thereby reducing the suspect pool[186] and assisting in constructing the image of an unidentified victim.[187] The results are not evidentiary like a fingerprint or hair analysis, but are investigational and designed to help the criminalist refine the search or contemplate another direction of inquiry.[188]

Every new scientific technique must be strenuously vetted before it can be considered accurate and legally sound, but some researchers are critical of forensic phenotyping since it can only provide a general outline of the suspect's appearance.[189] There is also a lack of peer-reviewed studies supporting the science.[190] Detractors further

180. Van Laan, *supra* note 157, at 39.

181. *Id.* at 36.

182. Koops & Schellekens, *supra* note 101.

183. *See Reports*, 23ANDME, https://www.23andme.com/dna-reports-list/ (last visited Nov. 11, 2018); *DNA FAQ*, ANCESTRY, https://www.ancestry.com/dna/#faqSection (last visited Nov. 10, 2018).

184. Koops & Schellekens, *supra* note 101, at 164.

185. *Id.* at 165.

186. Marks, *supra* note 163.

187. *Building on DNA: How Imaging Technology Could Help Solve Cold Cases*, ABC13.COM (Feb. 12, 2018), http://abc13.com/what-creating-sketches-from-dna-could-mean-for-solving-cold-cases/3052859/.

188. Marks, *supra* note 163.

189. Brooke Kaelin, *DNA Phenotyping: Revealing the Faces of Killers*, FORENSIC SCI. DEGREE (Nov. 30, 2016), https://www.forensicsciencedegree.org/dna-phenotyping-revealing-the-faces-of-killers/.

190. *See* Ashley Southhall, *Using DNA to Sketch What Victims Look Like; Some Call it Science Fiction*, N.Y. TIMES (Oct. 19, 2017), https://www.nytimes.com/2017/10/19/nyregion/dna-phenotyping-new-york-police.html. Under blind studies on the Parabon website, the following is listed: "The development of Snapshot was funded by the United States Department of Defense (DOD), specifically the Defense Threat Reduction Agency." *Frequently Asked Questions (FAQs) About Snapshot*, PARABON NANOLABS, https://snapshot.parabon-nanolabs.com/faq (last visited Nov. 10, 2018). As part of the development and validation process, Snapshot was tested "on thousands

raise questions about the tool's accuracy, racial bias, and infringement upon a person's privacy.[191] The disadvantage of relying upon a few genetic traits is that it places "actual people, innocent of wrongdoing, under criminal suspicion without any basis in fact or science."[192] As American Civil Liberties Union Senior Policy Analyst, Jay Stanley, has noted, phenotyping is "science fiction," and the technique should not be advertised until the discipline has been properly established.[193] In fact, these concerns are said to have stunted the worldwide adoption of forensic phenotyping.[194]

a. Accuracy

Various statistics are offered to predict the physical characteristics of an individual based upon his or her DNA.[195] Some traits can be forecasted with great accuracy while others are questionable; for instance, facial features such as the size or shape of the face, nose, and lips have solid genetic components, whereas height predictors are less accurate.[196] The following demonstrates the degree of accuracy for certain genetic traits:

Gender	100%
African Ancestry	71%
Asian Ancestry	88%
Caucasian Ancestry	90%

of out-of-sample genotypes and . . . [was] shown to be extremely accurate." *Id.* To see examples of Snapshot predictions from blind evaluation studies visit: https://snapshot.parabon-nanolabs.com/examples. *Example Blind Snapshot Predictions vs. Actual Photos*, PARABON NANOLABS, https://snapshot.parabon-nanolabs.com/examples (last visited Nov. 10, 2018). A visit to the link provided shows examples of sketches that have been used to identify suspects. *Id.* However, to date, there are no perspective, blind, peer reviewed studies in peer review journals cited on Snapshot. *See id.*

191. *See* Fatimah Waseem, *How a Reston-Based Technology Company is Helping Crack Cold Cases*, RESTON NOW (Feb. 14, 2018, 7:00 AM), https://www.restonnow.com/2018/02/14/how-a-reston-based-technology-company-is-helping-crack-cold-cases/.

192. Southhall, *supra* note 190.

193. Waseem, *supra* note 191 (citing Jay Stanley, *Forensic DNA Phenotyping*, AM. CIVIL LIBERTIES UNION (Nov. 29, 2016, 11:15 PM), https://www.aclu.org/blog/privacy-technology/medical-and-genetic-privacy/forensic-dna-phenotyping).

194. *See* Charles E. MacLean & Adam Lamparello, *Forensic DNA Phenotyping in Criminal Investigations and Criminal Courts: Assessing and Mitigating the Dilemmas Inherent in the Science*, 8 RECENT ADVANCES DNA & GENE SEQUENCES 104, 104 (2014).

195. *See* Van Laan, *supra* note 157, at 37.

196. *See id.* at 41.

Eye Color	76% - 99%
Hair Color	90%
Height	65%
Surname	19% - 44%[197]

The fallacy with these percentages is that looks are not solely based upon a person's DNA.[198] A person can alter their appearance in many ways: by changing their hair or beard color or style, contact lens color, weight, gender, or facial structure by plastic surgery.[199] Forensic phenotyping can only create an image that generally resembles the suspect because a person's individual appearance is determined by a complex interaction among a number of genes and can be changed drastically by choice; phenotyping cannot generate a picture that looks identical to the person.[200]

b. Racial Profiling

There is a concern that this forensic tool has the risk of perpetuating racial prejudices.[201] It is possible that biased law enforcement officials may misuse DNA information regarding an unknown suspect's race, and greater effort might be devoted to investigating matters involving certain minorities or strengthen the penchant for tunnel vision.[202] For instance, suppose the DNA results indicate a 60% probability that a suspect is of African descent and a 40% chance of being Caucasian; there is the risk of a biased analysis of the conclusion in that an investigator may be tempted to only investigate African suspects.[203] Critics also contend that since there are a larger number of people of color in the DNA databases, discriminatory police practices will make them more vulnerable to suspicion and surveillance.[204]

The counter argument is that concern about racial profiling is unfounded.[205] A DNA analysis of a specimen left at a crime scene is

197. Charles E. MacLean, *Creating a Wanted Poster from a Drop of Blood: Using DNA Phenotyping to Generate an Artist's Rendering of an Offender Based Only on DNA Shed at the Crime Scene*, 36 HAMLINE L. REV. 357, 365–70 (2013).

198. *See* Jay Stanley, *Forensic DNA Phenotyping*, AM. CIVIL LIBERTIES UNION (Nov. 29, 2016, 11:15 PM), https://www.aclu.org/blog/privacy-technology/medical-and-genetic-privacy/forensic-dna-phenotyping.

199. *Id.*

200. MacLean & Lamparello, *supra* note 194, at 108.

201. Koops & Schellekens, *supra* note 101, at 195.

202. *Id.* at 194.

203. *Id.*

204. MacLean, *supra* note 197, at 382–83.

205. *Id.* at 383.

colorblind and similar to a fingerprint.[206] The phenotype findings are based upon objective evidence and not a value judgment.[207]

c. Right to Privacy

Phenotyping is a form of genetic analysis, and one might argue that it comes within the protection against the disclosure of confidential medical information.[208] It is one thing to discover that a person has red hair and freckles but another to learn that an individual has a predisposition for a genetic disease[209] or a medical disorder that may be linked with crime, like alcoholism or drug misuse.[210] Two fundamental privacy questions can arise: the right not to know and personal autonomy—where do you draw the line as to what is relevant and should not be allowed?

The Fourth Amendment prohibits unlawful searches and seizures.[211] However, genetic material collected at a crime scene is abandoned property and enjoys no reasonable expectation of privacy.[212] Therefore, isn't the DNA phenotyping analysis like any other tangible evidence and the public's interest greater than the suspect's personal liberties?[213] These questions can be easily solved by appropriate legislative or judicial pronouncements restricting DNA phenotyping to externally visible characteristics.[214]

d. Legislative Response

DNA phenotyping is gaining traction around the world and various legislative bodies are taking notice,[215] with Europe being the most advanced in regulating its use.[216] The Dutch Parliament approved

206. *See id.* at 383–84.
207. *Id.* at 384.
208. *See* Koops & Schellekens, *supra* note 101, at 179.
209. One must be careful in using genetics as the sole factor in determining whether a person has a predisposition for developing cancer. *See* Nazneen Rahman, *Using Genetics to Predict Disease*, TRANSFORMING GENETIC MED. INITIATIVE (Oct. 28, 2016), http://www.thetgmi.org/genetics/genetic-predict-disease/. While genetic information is an important factor as to whether a person will develop cancer, it's only one part of the puzzle. *Id.* In fact, in the vast majority of people, it plays a very a minor part in solving the puzzle. *Id.*
210. *See* Koops & Schellekens, *supra* note 101, at 180–81.
211. U.S. CONST. amend. IV.
212. Van Laan, *supra* note 157, at 45.
213. *Id.*
214. MacLean, *supra* note 197, at 384.
215. *Id.* at 371.
216. *See* Van Laan, *supra* note 157, at 41–42.

DNA phenotyping in 2003 for the purpose of ascertaining visible characteristics of a suspect, such as gender and geographic origins.[217] Under its Code of Criminal Procedure, either the prosecutor or investigating judge can order the test but the application is limited to crimes punishable by four or more years in jail.[218]

Germany prohibits the use of predictive markers and mandates that genetic information be kept private.[219] This is partially based upon historic reasons associated with the persecutions of certain faiths during World War II.[220] The German Code of Criminal Procedure permits obtaining DNA samples from those accused of serious crimes or those perceived as likely reoffenders by the government.[221] The forensic analysis is allowed to search for certain short tandem sequences of DNA and determine if the profile matches any in the database.[222] The government, however, is prohibited from trying to predict hair color, skin color, or biogeographical ancestry.[223]

France has an expansive database and the Court of Cassation, the country's highest court of criminal and civil appeals, ruled that pigmentation markers for eyes, hair, and skin are permissible evidence at the trial of a serial rapist.[224] However, South African law restricts the use of DNA for molecular phenotyping.[225] The United Kingdom, where phenotyping has been the subject of research since the early 1990s, has no legislative scheme regulating the scientific

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217. MacLean, *supra* note 197, at 371.

218. *Id.* at 372.

219. Wolinsky, *supra* note 175.

220. *Id.*

221. Turna Ray, *Push for Forensic DNA Phenotyping, Ancestry Testing in Germany Raises Discrimination Concerns*, GENOMEWEB (May 4, 2018), https://genomeweb.com/policy-legislation/push-forensic-dna-phenotyping-ancestry-testing-germany-raises-discrimination.

222. *Id.* A short tandem repeat (STR) consists of repetitive sequence elements made up of between three to seven base pairs in length sprinkled around the human genome. By amplifying and analyzing these elements and comparing the ensuing STR profile to that of a referenced sample, the source of biological samples such as cells can be recognized and verified. *Short Tandem Repeat Analysis in the Research Laboratory*, PROMEGA (2012), https://promega.com/resources/pubhub/short-tandem-repeat-analysis-in-the-research-laboratory/.

223. Ray, *supra* note 221.

224. Wolinsky, *supra* note 175.

225. Nandi Slabbert & Laura Jane Heatherfield, *Ethical, Legal and Social Implications of Forensic Molecular Phenotyping in South Africa*, 18 DEVELOPING WORLD BIOETHICS 171, 177 (2018).

test.[226] Rather, it is permitted under the general legislative framework[227] and only allowed for testing ethic inferences.[228]

There is little judicial or legislative guidance in the United States on the use of DNA to predict a suspect's physical characteristics.[229] The failure of the courts to discuss the technique is understandable.[230] The absence of any peer reviewed studies and lack of general acceptance in the scientific community makes the DNA phenotyping inadmissible under either the *Frye*[231] or *Daubert*[232] standards. The lack of regulation by the legislature is more surprising.

The Federal government delegates the responsibility of establishing an index for DNA identification records to the Federal Bureau of Investigation for those convicted of or arrested of a crime so it can analyze DNA samples obtained from the crime scene, inspect the DNA from unidentified human remains, analyze DNA samples voluntarily submitted by family members of missing persons, and file DNA obtained under appropriate legal authority, so long as that DNA sample is voluntarily submitted for elimination purposes.[233] Notably, DNA phenotyping for purposes of apprehending an unknown suspect is absent from the list.[234] In this regard, one commentator reports that the Federal Bureau of Investigation has interpreted federal law to

226. Koops & Schellekens, *supra* note 101, at 172.

227. *See id*.

228. MacLean, *supra* note 197, at 373–74.

229. *See infra* notes 233–43 and accompanying text.

230. A Westlaw search for state and federal cases that mention "forensic phenotyping" or "forensics phenotyping" conducted on November 10, 2018, was unsuccessful in finding any relevant cases; only one case populated, and that case is more than three decades old. *See* People v. Young, 391 N.W.2d 270, 290 (Mich. 1986).

231. Frye v. United States, 293 F. 1013, 1014 (D.C. Cir. 1923).

232. *See* Daubert v. Merrel Dow Pharm., 509 U.S. 579, 588 (1993). One must remember that this test is merely an investigative tool whose results are not intended to be used in court as substantive evidence. *See id.*

233. 42 U.S.C. § 14132(a) (2012). Another section of the U.S. Code that addresses the collection and use of DNA identification information obtained from certain federal offenders is 42 U.S.C. § 14135a (2012). Section 14135a(a) allows for the collection of DNA samples from those individuals in custody, those on release, parole or probation, those already in CODIS, and those who refuse to provide a collection sample when requested. *Id.* § 14135a(a). Section 14135a(c) defines DNA analysis as an "analysis of the deoxyribonucleic acid (DNA) identification information in a bodily sample." *Id.* § 14135a(c).

234. *See* 42 U.S.C. § 14132(a) (2012).

permit determining sex and drawing inferences pertaining to ancestry and family kinship for the purposes of investigation.[235]

Only a handful of states have legislatively addressed DNA phenotyping; Rhode Island,[236] Indiana,[237] and Wyoming[238] ban the practice. Texas law provides that "[t]he information contained in the DNA database may not be collected, analyzed, or stored to obtain information about the human physical traits or predispositions for disease unless the purpose for obtaining the information is related to a purpose described by this section."[239]

Vermont's statute seems to impliedly permit the practice by allowing for the collection of DNA except for use in identifying a medical or genetic disorder.[240] Michigan has a similar approach, and it allows the police to collect DNA for identification purposes, but the sample may not be "analyzed for identification of any medical or genetic disorder."[241] The same argument can be made for Louisiana, whose statute also seems to allow DNA to be used to predict a suspect's physical characteristics.[242] Louisiana's law contains a definitions section, which describes a "DNA record" as "identification information stored in" a database for purposes of "generating investigative leads" including "characteristics . . . of value in establishing the identity of individuals."[243]

The excitement about DNA phenotyping and its ability to provide a new lead in a cold case is understandable.[244] Whether the technique

235. Erin Murphy, *Legal and Ethical Issues in Forensic DNA Phenotyping* 10 (Pub. L. & Legal Theory Res. Paper Series Working Paper No. 13-46, 2013).

236. 12 R.I. GEN. LAWS ANN. § 12-1.5-10(5) (West 2018) (noting that DNA samples shall never be used "for the purpose of obtaining information about the physical characteristics, traits or predispositions for disease.").

237. IND. CODE ANN. § 10-13-6-16 (West 2018) ("The information contained in the Indiana DNA data base may not be collected or stored to obtain information about human physical traits or predisposition for disease.").

238. WYO. STAT. ANN. § 7-19-404(c) (West 2018) ("The information contained in the state DNA database shall not be collected or stored for the purpose of obtaining information about physical characteristics, traits or predispositions for disease and shall not serve any other purpose[.]").

239. TEX. GOV'T CODE ANN. § 411.143(d) (West 2017).

240. *See* VT. STAT. ANN. tit. 20, § 1937(b) (West 2018).

241. MICH. COMP. LAWS ANN. § 28.175a (West 2018).

242. *Compare* MICH. COMP. LAWS ANN. § 28.175a (West 2018) (excluding all DNA sample DNA profiles from medical or genetic disorder analysis), with LA. STAT. ANN. § 15:611 (2018) (permitting state police to establish procedures for performing any type of testing on DNA samples so long as the completed analysis is used for "identification purposes").

243. LA. STAT. ANN. § 15:653 (2018).

244. *See supra* note 160 and accompanying text.

will revolutionize forensic investigations and gain general acceptance in the law enforcement community is still to be determined; however, there has been a definite increase in the number of articles published in scholarly journals which predict positive impacts from the use of forensic phenotyping in criminal investigations.[245]

D. CONCLUSION

The discovery of DNA evidence has dramatically changed the criminal justice landscape and offers objective evidence that can either convict or exonerate a suspect.[246] DNA provides the complete genetic code for a person, and it has been a vital part of forensic investigations since the late 1980s, helping to solve thousands of crimes.[247] The results are extremely accurate, and the odds of one person's DNA matching another are almost non-existent.[248]

It is standard protocol for law enforcement officials to take samples of blood, saliva, or skin cells found at a crime scene and compare them to DNA profiles contained in law enforcement databases with the purpose of fighting crime and combating terrorism.[249] The use of DNA in criminal investigations, however, is not without its controversies.[250] It is expected that experts will occasionally disagree about the analysis and statistical meaning of test results.[251] However, as new forensic applications for DNA evidence are being discovered, some of these techniques are raising complex ethical and legal issues.[252]

Familial DNA and forensic phenotyping are two of the latest discoveries involving the use of genetic materials in criminal investigations.[253] These techniques offer great promise, but they raise difficult ethical and legal issues about racial profiling, invasion of privacy, and test accuracy.[254] Little judicial or legislative guidance has been provided to address these concerns, which is understandable

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245. *See, e.g.*, Matheson, *supra* note 12, at 1061–64; Van Laan, *supra* note 157, at 48; MacLean & Lamparello, *supra* note 194, at 110–11.
246. *See How DNA Evidence Works*, FINDLAW, https://criminal.findlaw.com/criminal-procedure/how-dna-evidence-works.html (last visited Nov. 10, 2018).
247. *Forensic DNA*, *supra* note 26.
248. *Id.*
249. *See supra* notes 40–41, 64, and accompanying text.
250. *See supra* Part C.
251. *See supra* note 85 and accompanying text.
252. *See supra* Part C.
253. *See* discussion *supra* Sections C.1 and C.2.
254. *See* discussion *supra* Section C.2.

considering the recent emergence of these forensic tools.[255] It will be interesting to see how familial DNA and forensic phenotyping continue to develop, and whether the investigative methods gain uniform acceptance in the forensic community similar to that of criminal fingerprinting.[256]

255. *See* discussion *supra* Section C.2.d.
256. *See Fingerprints: An Overview*, NAT'L INST. OF JUSTICE, https://www.nij.gov/topics/forensics/evidence/impression/pages/fingerprints.aspx (last modified June 18, 2016).