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

Charles E. MacLean
lawreview@hamline.edu

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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

Charles E. MacLean*

I. DNA PHENOTYPING: THE SCIENCE AND ITS
INVESTIGATIVE USES

II. WHAT PHYSICAL CHARACTERISTICS CAN DNA
PHENOTYPING DETERMINE NOW, AND TO WHAT
LEVELS OF CERTAINTY?

III. WHAT PHYSICAL CHARACTERISTICS WILL DNA
PHENOTYPING LIKELY BE ABLE TO DETERMINE IN THE
FUTURE?

IV. LEGISLATIVE RESPONSES TO DNA PHENOTYPING
A. THE NETHERLANDS
B. THE FEDERAL REPUBLIC OF GERMANY
C. CANADA
D. BELGIUM
E. THE UNITED KINGDOM
F. AUSTRALIA
G. THE UNITED STATES
   1. INDIANA
   2. RHODE ISLAND
   3. VERMONT
   4. WYOMING
H. OTHER COUNTRIES EXPRESSLY OR IMPLICITLY PRECLUDE DNA
   PHENOTYPING AT PRESENT

V. STATES ALLOWING PHENOTYPING IN INVESTIGATIONS
   HAVE REAPED THE BENEFITS

* Chuck MacLean, B.A., M.B.A.-Finance (University of Minnesota), J.D. cum
   laude (William Mitchell College of Law), Assistant Professor of Law, Indiana Tech Law
   School. The author, a Minnesota felony prosecutor from 1990–2010, wishes to express his
   appreciation for the dedicated and able assistance and advice of Research Assistants Eugene
   Guerre, J.D. Candidate 2014, and James “Pat” Henry, J.D. Candidate 2014, both of Lincoln
   Memorial University, Duncan School of Law; Ryan Hansch, Assistant Redwood County
   (Minnesota) Attorney; and Dr. Chris Devery, New South Wales Police College.
VI. MINNESOTA’S DNA HISTORY: DNA USE AND ADMISSIBILITY HAS BEEN “DELIBERATE” AND, TO SOME, HAS LAGGED BEHIND THE SCIENCE, WITH THE LEGISLATURE OFTEN PUSHING THE COURTS

VII. OBJECTIONS TO THE FORENSIC USE OF DNA PHENOTYPING

A. OBJECTION: DNA PHENOTYPING VIOLATES THE SUBJECT’S RIGHT NOT TO KNOW

B. OBJECTION: DNA PHENOTYPING IS OR EXACERBATES RACIAL PROFILING

C. OBJECTION: DNA PHENOTYPING VIOLATES THE SUBJECT’S RIGHT TO PRIVACY

VIII. CONCLUSIONS AND RECOMMENDATIONS

WANTED FUGITIVE

Unknown male, with the following physical characteristics based on genetic testing of DNA left at crime scene: Caucasian, most-likely of Eastern European descent, left hand dominant, non-dimpled chin, no facial freckling, medium complexion, extremely near-sighted, prone to early onset male pattern balding, slightly angular face, quite slender, blue eyes, blond to reddish-blond hair, detached earlobe, and 21-30 years of age. This man should be considered dangerous.
Please note these are probabilistic estimates of his appearance; there may be some variation, and some characteristics may have been intentionally altered by the subject. The “photographs” at the top are an artist’s rendering of several possibilities for how the subject presently may appear.

Digital wanted posters, such as above, are already in use in a growing number of places, based only on genetic assessment of DNA phenotypes from biological specimens left by the unknown offender at a crime scene.1 Tough investigations are being solved across the world with these techniques, and the techniques are exploding in their ability to determine an increasing number of physical characteristics of the offender from DNA left behind at the scene.2 Although the techniques cannot yet determine all the characteristics in this mock wanted poster, that time is coming very soon, and the techniques already can provide valuable information regarding red hair, blue and brown iris color, likely geographic region of origin, and other characteristics.3 But in Minnesota, DNA analysis in criminal investigations, led by the highly-regarded Minnesota Bureau of Criminal Apprehension (“BCA”) laboratory, has been largely relegated to comparing known DNA genotypes extracted from arrested and convicted felons (“genetic fingerprints”) to DNA material found in unknown biological specimens left by offenders at crime scenes.4 This DNA genotyping focuses exclusively on portions of the DNA molecule that are prone to mutations over time, but that do not appear to control or contribute to any physical function, appearance, or other discernible characteristic of any person.5 DNA phenotyping, on the other hand, focuses exclusively on portions of the DNA molecule that control or contribute to physical characteristics, appearance, disease profiles, and the like.6

With DNA phenotyping then, testing can reveal many of the likely characteristics of the offender, including to one degree or another: skin, hair, and eye colors; geographical ancestry; gait; predisposition to smoking; left-handedness; and presence of or predisposition for certain diseases, including albinism and sickle cell anemia.7 If DNA phenotyping was used forensically

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1 See infra Part V (providing examples of murder cases solved with the assistance of DNA phenotyping).
2 See infra Part II (setting forth the physical characteristics that can be determined through DNA phenotyping).
3 See infra Table 1.
4 See infra Part VI (explaining the history of forensic DNA analysis in Minnesota).
5 See infra text accompanying notes 14–18 (explaining the use and features of DNA genotyping).
6 See infra Part II (explaining the uses of DNA phenotyping).
7 See infra Part II and Table 1 (setting forth the physical characteristics that can be determined through DNA phenotyping).
at the start of an investigation, one might imagine investigators disseminating a genetic “artist’s rendering” of the suspect’s physical characteristics (say, left-handed, Caucasian, freckled skin, red hair, and the like) that could help the investigators more quickly home in on the actual offender, and more quickly free innocent suspects who do not exhibit those physical traits. To this point, political correctness concerns akin to racial profiling and discrimination have squelched the adoption of DNA phenotyping to develop probable cause in investigations in all but a few nations.  

This article addresses Minnesota’s halting DNA admissibility track record to date, the current state of phenotyping science, the current literature on ethical concerns regarding DNA phenotyping, the rationales posed by nations supporting and shying away from phenotyping, and concludes with the author’s recommendations for Minnesota’s prosecutors, defense attorneys, criminal investigators, judges, forensic scientists and laboratories, and perhaps most crucially, the Minnesota Legislature.

The Minnesota Supreme Court has historically moved slowly in permitting the evidentiary use of DNA evidence. DNA phenotyping should not call forth the same judicial reticence since its use would be limited to the investigation only, it does not predict criminality from a certain ethnicity or set of physical characteristics, it is not akin to racial profiling but is akin to a fingerprint found at the scene or a physical description of a suspect provided by an eyewitness, and critically, no one now proposes that DNA phenotyping evidence per se be admitted into evidence at trial. By giving investigators advance notice of the likely physical characteristics of the offender, DNA phenotyping gives the investigators a powerful tool that can accelerate investigations, can secure the prompt release of innocent suspects not matching the subject’s phenotype, and will eventually be able to provide a phenotypic artist’s rendering of the suspect at the earliest stages of the investigation.

This article calls for Minnesota to accelerate the spade work now to evaluate the predictive and investigative value of DNA phenotyping, to devise appropriate limits on its use while not precluding it all together, and to begin the process of using DNA phenotyping during the investigative phases of several key criminal cases so that caselaw can be created. It will not be long before DNA science yields the ability to craft an unknown and unseen suspect’s facial image and body profile from the DNA the suspect left behind at the crime scene. Minnesota should be prepared.

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8 See infra Part VII (explaining the objections to the forensic use of DNA phenotyping).
9 See infra Part VI (setting forth the major Minnesota decisions regarding DNA admissibility).
I. DNA PHENOTYPING: THE SCIENCE AND ITS INVESTIGATIVE USES

DNA (deoxyribonucleic acid) is contained within each of our body’s cells and contains the blueprint from which our bodies are created and by which they operate.\(^{11}\) Other than identical twins, no two persons on Earth share identical DNA.\(^ {12}\) Thus, each of us is genetically unique, and it is this uniqueness and variety that have made DNA such a valuable forensic tool. DNA is used to identify the source of a biological specimen left behind at a crime scene by comparing the unknown biological specimen at the crime scene against a DNA database of known genotypes obtained from convicted persons.\(^ {13}\)

DNA genotyping has been used forensically since the mid-1980s,\(^ {14}\) and has been conditionally admissible in Minnesota criminal courts since the late 1980s.\(^ {15}\) Originally, at the FBI and BCA laboratories and elsewhere, forensic DNA genotyping began by using the RFLP methodology.\(^ {16}\) RFLP testing was a time-consuming process that required a substantially large biological specimen in order to return a valid DNA genotype for comparisons.\(^ {17}\) Other than the gender chromosome, RFLP only tested areas of the DNA strand that do not control or influence (that is, that do not “code for”) any observable characteristic or disease.\(^ {18}\)

In the late 1990s, forensic DNA laboratories, including the Minnesota BCA laboratory, began using PCR-STR,\(^ {19}\) which required a much smaller sample than RFLP required and returned results in a fraction of the time previously required for RFLP testing.\(^ {20}\) PCR-STR is capable of

\(^{11}\) **JOHN M. BUTLER, FORENSIC DNA TYPING: BIOLOGY, TECHNOLOGY, AND GENETICS OF STR MARKERS** 17 (2d ed. 2005) [hereinafter BUTLER, FORENSIC DNA TYPING].

\(^{12}\) See id. at 27 (discussing genetic variation in the human population).

\(^{13}\) CODIS is the Combined DNA Index System, a label that has come to refer to a database of known DNA genotypes held by the Federal Bureau of Investigation, and is populated by genotypes generated in FBI laboratories and genotypes uploaded by other law enforcement agencies across the country. The FBI website provides a brief description and history. See **Combined DNA Index System (CODIS)**, FED. BUREAU OF INVESTIGATION, http://www.fbi.gov/about-us/lab/codis/codis (last visited Sept 2, 2012).

\(^{14}\) The first forensic use of DNA genotyping in a criminal case occurred in England in 1986. BUTLER, FORENSIC DNA TYPING, supra note 11, at 3.

\(^{15}\) See infra Part VI (setting forth the major Minnesota decisions regarding DNA admissibility).

\(^{16}\) RFLP is an acronym for Restriction Fragment Length Polymorphism. RFLP is rather exhaustively discussed in a number of court opinions. See, e.g., Armstead v. State, 673 A.2d 221, 228 (Md. 1996).

\(^{17}\) BUTLER, FORENSIC DNA TYPING, supra note 11, at 5.

\(^{18}\) See id. at 22–23 (“Markers used for human identity testing are found in the non-coding regions either between genes or within genes.”).

\(^{19}\) PCR-STR is an acronym for Polymerase Chain Reaction-Short Tandem Repeats. PCR and PCR-STR are described in some detail in a leading Minnesota case. State v. Traylor, 656 N.W.2d 885, 888–90 (Minn. 2003).

\(^{20}\) BUTLER, FORENSIC DNA TYPING, supra note 11, at 4.
economically producing a reliable and replicable DNA genotype result using a very small sample size, much smaller than required with RFLP techniques. This is because PCR-STR is designed to extract the small amount of DNA material in the small sample and then amplify it by replicating it in a chemical reaction; it is the replicated DNA that is tested rather than just testing the original very small amount of DNA. PCR-STR, like RFLP, tests only portions of the DNA strand, other than gender determinants, that do not code for any physical characteristics. Almost all laboratories conducting forensic DNA genotyping tests today have discarded the RFLP technique in favor of the PCR-STR approach since PCR-STR has the same power RFLP has to discriminate among DNA genotypes, but at a fraction of the cost and with far less delay.

Many laboratories have pushed the PCR-STR boundaries into two new directions, y-STR testing and mitochondrial DNA testing. Y-STR testing uses a technique nearly identical to PCR-STR testing, but is capable of extracting and identifying a DNA genotype from the Y-chromosome (the “male fraction”) alone. Since y-STR addresses only the male fraction, it provides far less powerful frequency statistics than traditional PCR-STR approaches, but y-STR is very useful when there is a mixed female-male sample and the investigator wishes to focus only on the male genotype. Y-STR testing is also less powerful than traditional PCR-STR testing since all male members of a single lineage will share the same y-STR genotype. In a related direction, mitochondrial DNA tests only the DNA contained within the mitochondria of cells, and tests maternal lineage only. Mitochondrial DNA is very useful for hair shaft testing when the hair root is absent, thus precluding PCR-STR testing, and is very resistant to degradation over time. Mitochondrial DNA testing, like y-STR testing, yields frequency statistics far weaker than traditional PCR-STR testing techniques. Minnesota’s BCA

21 See id. at 4–5 (explaining that newer techniques, like PCR-STR, require a smaller sample size).

22 See Traylor, 656 N.W.2d at 889 (explaining the steps of PCR-STR analysis).

23 See BUTLER, FORENSIC DNA TYPING, supra note 11, at 22–23 (“Markers used for human identity testing are found in the non-coding regions either between genes or within genes.”).

24 See Traylor, 656 N.W.2d at 888 (explaining that due to problems with RFLP testing, the BCA has used a PCR-based approach since 1994).

25 BUTLER, FORENSIC DNA TYPING, supra note 11, at 201.

26 Id. at 202–03.

27 Thus, grandfather, father, uncle, and son all share the identical y-STR genotype. Id. at 213–14.

28 Id. at 247–48.

29 Id. at 241. In fact, mitochondrial DNA is often the preferred DNA test used for archaeological samples and samples to be tested after extended exposure to the elements. Id.

laboratory is one of just a few sites nationwide designated by the FBI as approved to serve as a regional laboratory to conduct mitochondrial DNA testing.31

In a rather recent twist, states have begun to engage in what has come to be known as “familial searching.”32 Familial searching is an option sometimes used when investigators are unable to achieve an exact or sufficient match or “hit” with a known sample in an existing DNA database.33 In this situation, using PCR-STR results, the database is queried for persons with genotypes that are a close, but imperfect, partial match with the genotype seized at the crime scene.34 The investigators then consider those persons with close but incomplete matches to be within the “family” of the accused, even though, quite obviously, at least some of those close but incomplete matches may not be related to the offender at all.35 The “family” members are then treated as investigative leads.36 Familial searching has engendered a rather heated battle regarding the privacy rights of those who are not in the DNA database but are identified through family members who are in the database.37 That ethical/legal concern is not at issue in the same way with DNA phenotyping, as it is currently used and envisioned, since no database is queried at all and no family members’ genotypes are retrieved and compared.38 Rather, DNA phenotyping is much more similar to an unknown fingerprint found at the scene, or an eyewitness’s physical description of the offender.39

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31 See MINN. DEP’T PUB. SAFETY FORENSIC SCI. SERV., ANN. REP. 1, 13 (2007).
33 Id. at 297–98.
34 Id.
35 Id. at 298.
36 Id.
39 See Amanda Pattock, It’s All Relative: Familial DNA Testing and the Fourth Amendment, 12 MINN. J.L. SCI. & TECH. 851, 871–72 (2011) (explaining that traditional police field work is still needed along with DNA testing).
II. WHAT PHYSICAL CHARACTERISTICS CAN DNA PHENOTYPING DETERMINE NOW, AND TO WHAT LEVELS OF CERTAINTY?

DNA phenotyping uses PCR-STR testing of SNPs to focus on portions of the DNA strand that code for certain physical characteristics, and the science of DNA phenotyping is certainly a moving target. Scientific findings unimaginable just a few years ago are now commonplace and in the future, phenotyping will be able to identify many physical characteristics not yet even on the drawing board. Take genetic diseases as an example. Twenty-five years ago, DNA analysis could identify just a very few genetic diseases. Indeed, modern DNA analysis has, for the first time, identified genetic components of many diseases that were once believed to have no genetic component at all. As of 2011, more than 2,500 tests for genetic diseases are available and provided by over 600 laboratories, up from just over 100 tests available from just over 100 laboratories in 1993. Between 2001 and 2011, on average, 175 new genetic tests were developed each year. It is not beyond reason to anticipate that, in the foreseeable future, DNA left at a crime scene could be examined and yield a rather complete probabilistic artist’s rendering and thoroughgoing physical description of the person who was the source of that DNA.

Similarly, though lagging far behind the work on genetic disease testing, DNA phenotyping has seen substantial growth in the variety of the physical characteristics discernible by DNA phenotype testing and in the robustness of the findings and predictions about externally visible characteristics (“EVCs”) identified through phenotyping. The following table (Table 1) serves as a snapshot of the state of DNA phenotyping in

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40 SNP is the acronym for Single Nucleotide Polymorphisms.
41 See Wojciech Branicki et al., Determination of Phenotype Associated SNPs in the MC1R Gene, 52 J. FORENSIC SCI. 349, 349 (2007); see generally JOHN M. BUTLER, ADVANCED TOPICS IN FORENSIC DNA TYPING: METHODOLOGY, at 347–62 (2011); see also BUTLER, FORENSIC DNA TYPING, supra note 11, at 182.
43 See id.
45 See id. (showing that about 750 tests were available in 2001 and about 2,500 tests were available in 2011 for an average over the ten years of 175 new tests per year).
46 Aside from gender, which is essentially 100% discernible via DNA testing, it appears that, at present, red hair color, blue iris color, and brown iris color are the three phenotypic test findings most widely accepted as reliable. Manfred Kayser & Peter M. Schneider, DNA-Based Prediction of Human Externally Visible Characteristics in Forensics: Motivations, Scientific Challenges, and Ethical Considerations, 3 FORENSIC SCI. INT’L: GENETICS 154, 156 (2009).
2012, arrayed by discernible characteristic and by the power of each prediction. In addition to those EVCs presented in Table 1, many EVCs have been the subject of fewer studies, including facial shape,\(^{47}\) chronological age,\(^{48}\) handedness,\(^{49}\) hair loss and patterned baldness,\(^{50}\) lip height and nose width at widest point,\(^{51}\) earlobe attachment characteristics,\(^{52}\) chin and cheek dimpling,\(^{53}\) and freckles,\(^{54}\) while some have been the subject of more robust research, such as cleft lip.\(^{55}\)

**Table 1: DNA Phenotyping (2012)**

<table>
<thead>
<tr>
<th>Externally Visible Characteristic</th>
<th>DNA-based Prediction</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>~100%</td>
<td>Currently, gender is the most accurately predictable EVC based on DNA markers—the length difference between the X-chromosomal and the Y-chromosomal copy of the amelogenin gene.(^{56}) However, in rare cases, some men are mistakenly identified as females because they happen to have Y-chromosomal deletion.(^{57}) Error rates vary within population zones and can be as low as .02% in Europe and as high as 1.8% in Southern Asia.(^{58})</td>
</tr>
</tbody>
</table>

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\(^{48}\) See, e.g., Dmitry Zubakov et al., *Estimating Human Age from T-cell DNA Rearrangements*, 20 CURRENT BIOLOGY R970 (2010).


\(^{53}\) See id.


\(^{56}\) Kayser & Schneider, supra note 46, at 156.

\(^{57}\) Id.

\(^{58}\) Id.
<table>
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<th>Externally Visible Characteristic</th>
<th>DNA-based Prediction</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race/Ancestry/Skin Color</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African</td>
<td></td>
<td></td>
</tr>
<tr>
<td>71%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>88%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90%</td>
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</table>

A 2011 study of 145 population samples from an Australian population (a self-administered buccal swab) was conducted to investigate the association of SNP genotypes with “self-declared genealogy.”

Evidence has proven, through separating different haplogroups, that mtDNA mutations have accumulated which now purport to show different geographic origins. The study is clear to point out, however, that “ancestry profiling will be subjective, not definitive, and will only be useful as an intelligence source rather than for identification.”

Further, debate has arisen as to the term “geographic origin” in comparison to “race”—the correct term is geographic origin. Thus, haplogroups have been developed for populations in Austria, Spain, Italy, and the United States, East Asian haplogroups for Japan, Korea, China, and Taiwan, Argentina, and, although less documented, haplogroups were developed for Australia and Oceania as well. The success rates are shown in Table 8 of the study and show rates of African (71%), Asian (88%), and Caucasian (90%).

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60 Id. (citation omitted).

61 Id.

62 Bert-Jaap Koops & Maurice Schellekens, *Forensic DNA Phenotyping: Regulatory Issues*, 9 Colum. Sci. & Tech. L. Rev. 158, 162 (2008); see also Natalie Quan, Note, Black and White or Red All Over? The Impropriety of Using Crime Scene DNA to Construct Racial Profiles of Suspects, 84 S. Cal. L. Rev. 1403, 1428–29 (2011) (explaining that the process of looking for and predicting physical traits oversimplifies race in that it is based on appearance alone and that geographic origin and race are indeed two different things).

63 McNevin et al., supra note 59, at 40.

64 Id. at 48.

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</thead>
<tbody>
<tr>
<td>Race/Ancestry/Skin Color continued</td>
<td>skin pigmentation are areas of substantial SNPs research in the scientific literature, with some substantial overlap.</td>
<td></td>
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<tr>
<td>Surname</td>
<td>19%–44%</td>
<td>Surnames, based on Y-chromosomal markers, can be identified to a limited extent. For example, in a study of British surnames (a sample of 150 randomly selected pairs of males who each shared a British surname), 19% of the surnames could be accurately predicted. Moreover, when dealing with less common names, the accuracy jumped to 34% (around 80 names). A recent law review article cited another study in which a researcher claimed a genotype occurring in 44% of men with the surname Sykes, which did not occur in other surnames.</td>
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70 Id.

Aside from gender, iris color, particularly blue and brown eye color, can be predicted based solely on DNA evidence with its predictability high enough to be useful for law enforcement.\textsuperscript{72} Predictability of eye color varies between geographic regions, with Europe displaying the highest, widest variation of eye pigmentation traits.\textsuperscript{73} Researchers conducted a study using the IrisPlex system to test its effectiveness across Europe (EUREYE) using a total of 3804 Europeans in which the average effective prediction rate, using a probability threshold of 0.7, was 94\% across all seven European populations.\textsuperscript{74} Specifically, the accuracy rate varied between 83\% (Italy) and 95.5\% (Greece) with an overall prediction error rate of 12.5\% without taking into account prediction probability.\textsuperscript{75} As the prediction probability threshold increases, so does the amount of unpredictable individuals. Thus, at $p \geq 0.7$, the IrisPlex is the most accurate with a loss of only 865 samples from the 3804 pool of individuals.\textsuperscript{76} Similar studies have also been conducted with similar results.\textsuperscript{77}

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<th>Externally Visible Characteristic</th>
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<tbody>
<tr>
<td>Eye Color</td>
<td></td>
<td></td>
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<tr>
<td>Norway</td>
<td>76%-99%</td>
<td></td>
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<tr>
<td>Estonia</td>
<td></td>
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<td>UK</td>
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<td>France</td>
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<tr>
<td>Italy</td>
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<tr>
<td>Greece</td>
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<tr>
<td>Spain</td>
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\textsuperscript{72} Kayser & Schneider, supra note 46, at 156.


\textsuperscript{74} Walsh et al., Eye Colour Prediction, supra note 73, at 337.

\textsuperscript{75} Id. at 334.

\textsuperscript{76} Id. at 337.

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<tbody>
<tr>
<td><strong>Hair Color</strong></td>
<td>~90%</td>
<td>A single gene located on chromosome 16, MC1R, which encodes the melanocortin 1 receptor, has a strong influence on hair color. Because some of its alleles are closely tied to overproducing pheomelanin, it is also closely tied to red hair and fair skin. Overproduction of pheomelanin “manifests in red hair and fair skin” and variation is rather high among Caucasians. According to one study, three variants of the MC1R gene so strongly accompany red hair and pale skin that the probability of predicting red hair approaches 90%. In another study, variants R151C and R160W affected near 85% of the redheads showing that the discovery of one of these variants could be very significant in law enforcement study.</td>
</tr>
<tr>
<td><strong>Adult Body Height</strong></td>
<td>~65%</td>
<td>Adult body height is an EVC that has been found to be more complex than those such as eye color and hair color. Its inheritability has been estimated to be around 80% but there are also other genetic factors, as well as environmental factors, that affect body height. Accordingly, all the genetic variants found so far explain only a small proportion of population height variance—0.4cm. A recent article identified 34 of 54 loci with strong statistical evidence of predicting</td>
</tr>
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78 Branicki et al., *supra* note 41, at 349.
79 *Id.*
81 Branicki et al., *supra* note 41, at 352.
82 Magdalena Marciańska & Wojciech Branicki, *The Search for Genetic Height Markers for Forensic Purposes*, 78 Probs. of Forensic Sci. 175, 175–76 (2009); see also Pulker et al., *supra* note 52, at 103.
84 *Id.*
One ought not ignore the nature versus nurture dichotomy. For example, although one’s genes—nature—may predispose toward a height over six feet, one’s environment—nurture—may amplify or mute that predisposition. That is, a person genetically predisposed to being tall may yet grow up to be short where the person’s environment, driven for example by poverty and poor nutrition, stunts the otherwise predictable growth.88 On a related point, one genetically identifiable as blue-eyed or blond-haired, may artificially change eye color or hair color by using contacts or hair dye, and thus change what DNA phenotyping would lead an observer to predict.89 Furthermore, most physical characteristics are not controlled by a single chromosome, but are influenced by multiple chromosomes working together, and are as influenced by environmental factors.90

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85 Yurii S. Aulchenko et al., Predicting Human Height by Victorian and Genomic Methods, 17 EUR. J. OF HUM. GENETICS 1070, 1072 (2009).
86 Id. at 1073.
87 Id. at 1074.
89 This could pose challenges for using phenotype data in announcing a likely physical description of the offender, but that can be managed by including a notice that appearance can be modified intentionally by the subject.
90 Koops & Schellekens, supra note 62, at 164–65. Although this is a substantial complexity, scientists are quantifying these interrelationships in increasingly complex genetic combinations every year. See id.
III. WHAT PHYSICAL CHARACTERISTICS WILL DNA PHENOTYPING LIKELY BE ABLE TO DETERMINE IN THE FUTURE?

As one can plainly see from the stratospheric growth in the number of tests and number of EVCs discernible or predictable through DNA phenotyping approaches in the recent past, one can expect that someday soon, investigators could use a crime scene DNA sample to generate a probability-weighted physical description of the source of that DNA that could include all or most of the following EVCs: gender, race or ethnicity, skin pigmentation, eye color, natural hair color, hair texture, nose width, dimpling in chin and cheek, earlobe attachment, adult height, patterned baldness, chronological age, natural dominant hand, lip height, freckling, and in some cases, even surname. And this forecast may be conservative. Although nature and nurture work in tandem to contribute toward each person’s appearance, and although many genes collectively affect most EVCs rather than each EVC being a product of a single gene, scientists are making incredible strides exploring and identifying those interrelationships. Scientists are still exploring the entire human genome at a rather macro scale. For example, human chromosome 1 was not indexed until 2006. The future of SNPs science and DNA phenotyping is already upon us, and the future promises much more.

IV. LEGISLATIVE RESPONSES TO DNA PHENOTYPING

As the science improves, and as the related ethical issues become clearer, legislatures across the world have started to respond. The most definitive current statutory response is the Dutch law.

A. The Netherlands

The Netherlands specifically allows the use of DNA phenotyping, but limits such use to externally visible characteristics only, most notably, gender and geographic origin. The Netherlands expressly limits
phenotyping to such characteristics that the suspect had since birth, and which anyone can see. 95 “DNA investigation means the research of cell material which is only targeted at comparing DNA profiles or determining externally perceptible personal characteristics of the unknown suspect.” 96 Under the Dutch Code of Criminal Procedure, both the public prosecutor 97 and the investigating judge 98 have the power to order a DNA investigation to determine externally perceptible personal characteristics, but only for offenses punishable by a maximum imprisonment of four years or more. 99

Although the Act does allow testing for characteristics other than just geographic origin and gender, a separate rule provides that a Decree allowing for more characteristics shall not be enacted earlier than four weeks after the draft has been submitted to both chambers of the Dutch Parliament. 100 The Dutch Act even protects the DNA subject’s privacy and requires that the DNA subject’s “right not to know” be respected. 101 “[I]f it is uncertain that the source [suspect] knows about the trait, it may not be investigated” and thus the only characteristics that may legally be discernible in the Netherlands “should” be those noticeable and visible at birth. 102 Therefore, DNA phenotype findings regarding hereditary disorders and susceptibility to diseases are prohibited, since the suspect has a “right not to know” about any of these. 103 This respects the privacy of the suspect, that is, the privacy of the source of the DNA specimen at the crime scene. Thus, there are essentially four closely related restrictions in the Act. To be legally testable using DNA phenotyping in the Netherlands, any physical characteristic must be (1) externally perceptible; (2) visible; (3) present at the time of and since birth; and (4) publicly perceptible.
B. The Federal Republic of Germany

Germany allows DNA investigation but only for certain enumerated purposes. The German Code of Criminal Procedure ("GCCP") allows investigation of DNA only for the determination of "parentage," the determination of whether the DNA came from the suspect or the victim, and the determination of gender.\textsuperscript{104} Gender was a later amendment to the GCCP for two reasons: (1) it is helpful in the case of an unknown suspect; and (2) gender can readily be seen and does not require special protection when compared to "genetic vulnerabilities."\textsuperscript{105} Interestingly, German investigations of DNA are not expressly limited to "non-coding" sequences of DNA, thus the admissibility of DNA evidence in German courts does not appear to be dependent on whether the test results are drawn from coding or non-coding DNA segments.\textsuperscript{106} Although this appears broad, it also appears that gender is the only phenotype currently allowed under the GCCP.

C. Canada

In Canada, forensic DNA testing is limited by statute to non-coding regions only,\textsuperscript{107} and thus DNA phenotyping is implicitly precluded.

D. Belgium

In Belgium, DNA testing is limited by the country’s Code of Criminal Procedure to only address non-coding portions of DNA; DNA testing of any other type is a criminal offense in Belgium.\textsuperscript{108}

E. The United Kingdom

The United Kingdom uses its Forensic Science Services to provide "intelligence about the physical appearance of the offender."\textsuperscript{109} Currently, permissible DNA phenotyping in the United Kingdom includes only an ethnic inference test (to determine likely race or ethnicity, defined as membership in one of the five predominant British ethnic groups: white European, Afro-Caribbean, Indian, Southeast Asian, and Middle Eastern),

\textsuperscript{104} Koops & Schellekens, supra note 62, at 170; STRAFPROZESSORDNUNG [StPO] [CODE OF CRIMINAL PROCEDURE], April 7, 1987, BUNDESGESETZBLATT, Teil I [BGBl. I] 1074, as amended, art. 81e, available at http://www.iuscomp.org/gla/statutes/StPO.htm#81e (last visited July 11, 2012).

\textsuperscript{105} Koops & Schellekens, supra note 62, at 170.

\textsuperscript{106} Koops & Schellekens, supra note 62, at 170.

\textsuperscript{107} Koops & Schellekens, supra note 62, at 167 (citing CODE D’INSTRUCTION CRIMINELLE [CODE OF CRIMINAL PROCEDURE] art. 44ter § 1).

\textsuperscript{108} Koops & Schellekens, supra note 62, at 172 (quotation omitted).
and a red-hair test based on the MC1R gene.110 The Forensic Science Services is researching further methods to determine skin color, facial structure, and height.111

F. Australia

Forensic DNA profiling is often used by Australian law enforcement and its admissibility is clear when DNA taken from a scene is merely compared to a sample taken from a suspect.112 The government agency CrimTrac currently permits DNA profiling of semen, blood stains from burglaries, and blood stains from stabbings.113 These do not normally involve information about physical traits, and there have been no documented cases of “familial matching” being used at trial in Australian criminal prosecutions, although it has been used in investigations, most notably the “Falconio murder” in the Northern Territory.114 An effort is currently underway to “harmonize” the numerous Australian acts and statutes addressing DNA testing and admissibility.115 Although the current Australian law permits only DNA genotyping, at least one key commentator is calling for amending the current Australian law to permit determination of EVCs by way of DNA phenotyping.116

G. The United States

There is presently no federal legislation on the use of DNA phenotyping in criminal investigations, and most states follow this same pattern117 except Indiana, Rhode Island, Vermont, and Wyoming.

1. Indiana

Indiana statutes provide: “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.”118 Thus, investigators and others cannot mine DNA database samples and information to gather EVC and disease information, but that may not preclude an investigator from obtaining a new sample, one not yet in nor intended to be logged into the

110 Id. at 172–73.
111 Id. at 173.
113 See id. (stating that CrimTrac provides these three examples of DNA profiling).
114 Id. at 66–67.
115 See id. at 71.
116 Id. at 77–78.
117 Koops & Schellekens, supra note 62, at 171.
118 IND. CODE ANN. § 10-13-6-16 (West 2012).
DNA database (say, a sample deposited at a crime scene), and determining the EVCs associated with that new sample. There is no caselaw to guide that interpretation.

2. Rhode Island

Similarly, but not identically, Rhode Island statutes provide: “DNA samples and DNA records collected under this chapter shall be used only for law enforcement identification purposes or to assist in the recovery of identification of human remains from disasters or for other humanitarian identification purposes, including identification of missing persons.” 119 Furthermore, “DNA samples and DNA records . . . shall never be used under the provisions of this chapter for the purpose of obtaining information about physical characteristics, traits or predispositions for disease.” 120 It is reasonable to construe this somewhat different statutory language to limit the use not just of DNA database information, but also to limit the use of DNA samples collected by law enforcement. The statute thus seems, as written, to preclude DNA phenotyping of new samples collected at crime scenes in Rhode Island. Again, there is no caselaw to guide that interpretation.

3. Vermont

Vermont statutes appear to similarly impose broader restrictions, extending beyond information already in the DNA database, and including samples newly collected at crime scenes. The law states: “Analysis of DNA samples is authorized . . . to type the genetic markers from DNA samples for law enforcement identification purposes.” 121 However, “[a]nalysis of DNA samples obtained pursuant to this subchapter is not authorized for identification of any medical or genetic disorder.” 122

4. Wyoming

Wyoming statutes provide:

The division shall authorize access to or disclose DNA records and DNA samples collected in the state DNA database only in the following circumstances:

(i) To criminal justice agencies for law enforcement identification purposes;

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119 R.I. GEN. LAWS ANN. § 12-1.5-10(4) (West 2012).
120 R.I. GEN. LAWS ANN. § 12-1.5-10(5) (West 2012).
122 V T. STAT. ANN. tit. 20, § 1937(b) (West 2012).
(ii) For criminal defense purposes, to a defendant who shall have access to samples and analyses performed in connection with the case in which such defendant is charged;
(iii) For a population statistics database, identification research and protocol development or quality control purpose, and then only if personal identifying information is removed; and
(iv) To assist in the recovery or identification of human remains from mass disasters or for other humanitarian purposes, including identification of living missing persons.123

The law further provides:

Only DNA records which directly relate to the identification characteristics of individuals shall be collected and stored in the state DNA database. 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 predisposition for disease . . . “124

Obviously, the Wyoming legislature has, for the moment at least, limited the use of DNA collection and databases to standard DNA genotyping for identification and statistical significance testing only. The Wyoming legislature, just as obviously and overtly, precludes the use of DNA collection and databases “for the purpose of obtaining information about physical characteristics, traits, or predisposition for disease.”125 Thus, the Wyoming approach is consistent with many legislatures that have, so far, taken an “overcautious” approach to DNA phenotyping, even for investigative purposes only.126

H. Other Countries Expressly or Implicitly Preclude DNA Phenotyping at Present

Both Spain and South Africa limit DNA testing to non-coding regions of DNA only,127 thus implicitly precluding DNA phenotyping at present.

123 WYO. STAT. ANN. § 7-19-404(a) (West 2012).
124 WYO. STAT. ANN. § 7-19-404(c) (West 2012).
125 Id.
126 Koops & Schellekens, supra note 62, at 158.
127 See Resources: Laws Overview, FORENSICDNAETHICS, http://forensicdnaethics.org/resources/laws (last visited July 18, 2012) (ForensicDNAethics is a website maintained by the Forensic DNA Phenotyping Project at the Penn Center for Bioethics).
V. STATES ALLOWING PHENOTYPING IN INVESTIGATIONS HAVE REAPED THE BENEFITS

Several states have successfully concluded difficult murder cases with the assistance of DNA phenotyping. A few notable examples follow.

In California, the investigation of the murders of Leslie Mazzara and Adriane Insogna stalled after police investigated over 1,300 individuals and tested 218 DNA samples.\textsuperscript{128} After DNA phenotyping analysis, law enforcement announced the suspect was 96% Northern European and 4% Southeastern European, and, unrelated to the DNA testing, announced the suspect also smoked an unusual brand of cigarettes; the suspect, believing at this point that he was on the verge of getting caught, turned himself in.\textsuperscript{129}

In Colorado, Susannah Chase was beaten to death in 1997.\textsuperscript{130} In 2004, after years of little progress in the investigation, and with no “hits” in the national DNA database of convicted persons’ genotypes, DNA phenotyping of a biological specimen at the scene was conducted, and officers publicly announced a racial profile of the killer based on those phenotyping results.\textsuperscript{131} The testing indicated the killer was Hispanic or Native American and, based on that announcement, the killer was caught, his DNA was verified genotypically as matching that left at the murder, and he was tried and convicted.\textsuperscript{132} The killer’s DNA had been collected years earlier as a result of a separate felony conviction, but a backlog on DNA testing had led to the killer’s DNA genotype not being identified and entered into the DNA database.\textsuperscript{133}

In Louisiana, a series of murders and sexual assaults occurred from the late 1990s to the early 2000s.\textsuperscript{134} Authorities had a difficult time profiling the suspect because eyewitnesses identified a White suspect while other evidence seemed more consistent with an African-American perpetrator.\textsuperscript{135} DNA phenotyping confirmed that the suspect was 85% sub-Saharan African and 15% Native American—there was 0% chance the suspect was


\textsuperscript{129} The Murders of Leslie Mazzara and Adriane Insogna, FORENSICDNAETHICS, http://forensicdnaethics.org/resources/cases/44-cases-6 (last visited July 18, 2012); see also Doyle, supra note 128.


\textsuperscript{131} The Murder of Susannah Chase, FORENSICDNAETHICS, http://forensicdnaethics.org/resources/cases/46-cases-8 (last visited July 18, 2012); see also Torpy, supra note 130 (stating that police released a DNA racial profile of the killer in 2004).

\textsuperscript{132} The Murder of Susannah Chase, supra note 131.

\textsuperscript{133} Id.


\textsuperscript{135} Id.
Caucasian. In fewer than two months, police arrested an African-American man, Derrick Lee Todd, whom police were also able to link to two other murders.  

VI. MINNESOTA’S DNA HISTORY: DNA USE AND ADMISSIBILITY HAS BEEN “DELIBERATE” AND, TO SOME, HAS LAGGED BEHIND THE SCIENCE, WITH THE LEGISLATURE OFTEN PUSHING THE COURTS  

An exhaustive recounting of the history of DNA admissibility in Minnesota is unnecessary here, since there are clear and authoritative sources on the topic. The following timeline, Table 2, pinpoints the major Minnesota decisions on point.  

**TABLE 2: MINNESOTA’S DNA JURISPRUDENCE – A TIMELINE**  

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
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<tbody>
<tr>
<td>1989</td>
<td><em>Schwartz</em>&lt;sup&gt;139&lt;/sup&gt; Affirming Minnesota will apply the <em>Frye</em> test to DNA.</td>
</tr>
<tr>
<td>1989</td>
<td>Admitting the <em>Kim</em> standard for admitting probability data.</td>
</tr>
<tr>
<td>1989</td>
<td>Minn. Stat. § 634.25&lt;sup&gt;140&lt;/sup&gt; Legislatively proclaiming DNA evidence is admissible.&lt;sup&gt;141&lt;/sup&gt;</td>
</tr>
</tbody>
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136 Id.  
137 Id.  
139 State v. Schwartz, 447 N.W.2d 422, 424-25, 428-29 (Minn. 1989). RFLP analysis was used in this case. Id. at 425.  
141 Of course, as a matter of separation of powers, particularly within the context of Minnesota’s state government, the Legislature cannot dictate to the Judiciary what is admissible in Minnesota courts. The Minnesota Supreme Court somewhat pointedly said as much two years after this legislative enactment. State v. Nielsen, 467 N.W.2d 615, 620 (Minn. 1991). This statute is certainly not the only time the Minnesota Legislature has enacted legislation expressly intending to set judicial procedures. See, e.g., *Minn. Stat.* § 631.07 (2012) (purporting, legislatively, to give the prosecution a right to a rebuttal closing argument). Note that the Minnesota Supreme Court later revised its own Minnesota Rules of Criminal Procedure to give the prosecution this same right. *Minn. R. Crim. P.* 26.03 subdiv. 12(j).
Finding the trial court’s failure to grant defendant a DNA hearing was an error.

Allowing DNA probabilities evidence.

Allowing DNA probabilities; precluding expert conclusions.

Allowing “consistent with” but not “match” testimony.

Allowing qualified expert to call a “match.”

Allowing “reasonable degree of scientific certainty” testimony.

Allowing qualified expert to call a “match.”

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142 Nielsen, 467 N.W.2d at 619–20 (however, the Court found the error harmless). RFLP analysis was apparently used in this case. See id. at 617.

143 State v. Jobe, 486 N.W.2d 407, 419–20 (Minn. 1992) (allowing probability evidence based on the Schartz requirements). RFLP analysis was used in this case. Id. at 413–14.

144 State v. Johnson, 498 N.W.2d 10, 14–15 (Minn. 1993) (allowing DNA probability evidence, relying on Schwartz, but declining to allow an expert to offer conclusions to the jury). RFLP analysis was apparently used in this case. See id. at 14.

145 State v. Alt, 504 N.W.2d 38, 49–54 (Minn. Ct. App. 1993) (affirming the conservative modified ceiling principle for calculating probabilities, allowing expert testimony that DNA from the scene was “consistent with” defendant’s DNA, but precluding expert testimony to the effect of a declaration of a “match” “to a reasonable degree of scientific certainty”). RFLP analysis was used in this case. Id. at 40.

146 State v. Bloom, 516 N.W.2d 159, 167–68 (Minn. 1994) (allowing the expert to indicate a “match,” but precluding the expert from testifying that the DNA genotype was “unique”). RFLP analysis was apparently used in this case. See id. at 164. Bloom, in a sense, was the Court’s response to yet another legislative pronouncement purporting to control judicial procedures, this time by trying to preclude the Court from limiting the admissibility of DNA statistical probability evidence if the limits violated a statutory pronouncement on the same type of evidence. Minn. Stat. § 480.0591 subdiv. 6(4) (2012); 1993 Minn. Laws, ch. 326, art. 7, § 12.

147 State v. Perez, 516 N.W.2d 175, 176 (Minn. 1994) (allowing “reasonable degree of scientific certainty” testimony by a properly qualified expert). RFLP analysis was apparently used in this case. See id.
Defense counsel may decline DNA hearing or challenge.

PCR-STR, “new” science, required pretrial *Frye* hearing.

The DNA Advisory Board (DAB) standards control.

Compliance with the Technical Working Group on DNA Advisory Board (TWGDAM) guidelines is not required.

PCR-STR statistics may be reported via the product rule.

Minor lab inconsistencies did not yield inadmissibility.

Mandatory DNA testing of convicts is constitutional.

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148 State v. Bauer, 516 N.W.2d 174, 175 (Minn. 1994) (allowing a qualified expert to announce a “match”), RFLP analysis was apparently used in this case. See id.

149 State v. Schneider, 597 N.W.2d 889, 894 (Minn. 1999) (RFLP and PCR) (finding that defense counsel’s tactical decision to refrain from demanding a pretrial *Frye* hearing, and failure to object to admission of DNA evidence, was not ineffective assistance of counsel). Both RFLP and PCR analyses were used in this case. Id. at 893.

150 State v. Roman Nose, 649 N.W.2d 815, 821–23 (Minn. 2002) (holding that a pretrial *Frye* admissibility hearing was required prior to admitting PCR-STR evidence, and failure to hold the hearing was error). The PCR-STR method was used in this case. Id. at 817–18.

151 State v. Traylor, 656 N.W.2d 885, 897 (Minn. 2003) (holding that DAB standards must be followed for the laboratory results to be admissible). The PCR-STR method was used in this case. Id. at 890.

152 State v. Kromah, 657 N.W.2d 564, 566–67 (Minn. 2003) (holding that compliance with TWGDAM guidelines is not a prerequisite for admissibility). The PCR-STR method was used in this case. Id. at 565.

153 State v. Miller, 666 N.W.2d 703, 711 (Minn. 2003) (finding that DNA statistical probabilities for PCR-STR testing should be computed via the product rule method). The PCR-STR method was used in this case. Id. at 710.

154 State v. Jones, 678 N.W.2d 1, 13–15 (Minn. 2004) (holding that miscellaneous minor procedural inconsistencies did not compromise reliability or admissibility of PCR-STR test results). The PCR-STR method was used in this case. Id. at 7.

155 State v. Bartylla, 755 N.W.2d 8, 14–18 (Minn. 2008) (holding that a statute authorizing the seizure of biological specimens from convicted persons for DNA typing and cataloging was not unconstitutional, since under the totality of the circumstances, the search
Various Minnesota legislators have continued to seek legislative fixes for various perceived shortcomings in DNA testing and admissibility. For example, a bill authorizing familial DNA searching was introduced in 2011 but did not garner a single hearing, and various bills seeking to amend the data practices and other governmental treatment of information in the DNA database have recurrently been proposed.

VII. OBJECTIONS TO THE FORENSIC USE OF DNA PHENOTYPING

Eyewitnesses’ physical descriptions of offenders have long been used during the investigation phase to rule in and rule out suspects. And investigators have often released to the public those eyewitnesses’ physical descriptions of the offenders to seek leads. Investigators have also converted those eyewitness physical descriptions into artist renderings or facial composites of the offender and released those, also seeking leads. Each of these techniques has long been recognized as helpful to investigations and as free from the racial profiling or DNA dragnet labels some commentators have attributed to DNA phenotyping.

With all of DNA phenotyping’s robust scientific power comes substantial ethical issues, including a person’s right not to know, racial profiling, and privacy rights. These issues may be substantial, but are surely not insurmountable, and can likely be mitigated by carefully crafted legislative limits or by common law.

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156 H.F. 981, 87th Leg. Sess. (Minn. 2011).
157 See, e.g., H.F. 901, 86th Leg. Sess. (Minn. 2009); H.F. 3804, 84th Leg. Sess. (Minn. 2006).
158 McNevin et al., supra note 59, at 39.
159 These physical descriptions of offenders provided by eyewitnesses have long been under attack as unreliable. See Laura Engelhardt, The Problem with Eyewitness Testimony: Commentary on a Talk by George Fisher and Barbara Tversky, 1 STAN. J. LEGAL STUD. 25 (1999). DNA phenotyping does not share any of the psychological shortcomings of eyewitness descriptions.
A. Objection: DNA Phenotyping Violates the Subject’s Right Not to Know

One of the fundamental issues at the heart of DNA phenotyping arises from the fact that coded information within our DNA contains sensitive information besides externally visible characteristics (“EVCs”), such as disease propensities, psychological predispositions, and other medical information the DNA source may not otherwise know, may not wish to know, and may not wish others to know. The Dutch Civil Code specifically addresses that concern: “[I]f the patient indicates that he does not want to receive information, then this is not provided, unless the potential resulting prejudice to himself or others outweighs the patient’s interest in not knowing.”

Thus, if an individual learns through DNA information that he has propensities or susceptibility to certain genetic diseases the individual wished not to know, then “forensic phenotyping may breach a basic principle in medical law, the right not to know.” According to the Universal Declaration of the Human Genome and Human Rights: “The right of each individual to decide whether or not to be informed of the results of genetic examination and the resulting consequences should be respected.”

The central question here is whether the government’s criminal investigation interests, the victim’s interests, and the public interests outweigh the subject’s wish not to know. Of course, as will be discussed in the recommendations below, this right-not-to-know dilemma and objection is completely eliminated by legislation or judicial opinion that limits DNA phenotyping to assessing only externally visible characteristics, which by their nature as externally visible are already known to the subject.

B. Objection: DNA Phenotyping Is or Exacerbates Racial Profiling

Some opponents argue that DNA phenotyping, specifically in regard to the DNA databanks currently being stored, make racial minority communities specifically vulnerable to suspicion and surveillance. They argue this may lead to discrimination since there is already a disproportionately larger number of samples in DNA databases that were provided by persons of color, which they argue was caused by

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161 Koops & Schellekens, supra note 62, at 174.
162 Koops et al., supra note 80, at 220 (quoting BW art. 7:449).
163 Koops & Schellekens, supra note 62, at 175.
164 Universal Declaration on the Human Genome and Human Rights, U.N.E.S.C.O. Res. 29C/31, 30th Sess., (Vol. 1), art. 5(c) (Nov. 11, 1997).
165 Koops & Schellekens, supra note 62, at 175.
“discriminatory police practices.” 167 One commentator even argued that when an investigator uses “any kind of evidence of the race and/or ethnicity of an individual to make an initial determination whether to include that person as a possible suspect, one is engaging in profiling.” 168

 Others argue that DNA phenotyping will make law enforcement even more dependent upon racial identifiers and that it will arguably have a disproportionately discriminatory effect on minority communities because it could give rise to the notion that members of some races commit crimes more than members of other races. 169 If one sees DNA phenotyping as providing an essential connection between race, ancestry, and crime, that belief will only reinforce the very stereotypes that society has been trying to wipe out for years, and it could potentially create a scientific argument that one race is more prone to commit crimes than others. 170 This not particularly nuanced argument holds that because law enforcement will be even more prone to “profile” due to DNA phenotyping and because law enforcement is arguably discriminatory in its enforcement of the law, DNA phenotyping simply exacerbates the racial issues that have plagued the United States. 171

 A further argument is that DNA-based race predictions are flawed because, although the genetic markers are selected to reveal the most information regarding physical appearance, race and physical traits are, indeed, not exactly the same thing. 172 Furthermore, since DNA phenotyping assesses physical traits such as hair color, eye color, height, and facial structure, these predicted physical traits are assumed to coincide with racial groups—a gross over-simplification. 173 One author notes that there is simply no one genetic marker that one race possesses but all the other races do not; eye color, skin color, and hair color are not absolute to each race. 174 Further, evolution has caused differences in phenotypes because groups have had to adapt based on the conditions of wherever the groups resided, such that groups with different genetic markers may share some of the same phenotypic traits due to environmental factors, something for which DNA phenotyping cannot account. 175

 The stated ethical concern that DNA phenotyping is simply racial profiling is a mirage. DNA phenotyping results are not used to argue that persons of a certain race are more prone to commit certain types of crimes or are more prone to criminality in general. Rather, DNA phenotyping of a

167 Roberts, supra note 166, at 582–83; see also Koops & Schellekens, supra note 62, at 194 (discussing the idea that DNA information may result in police discrimination).
169 Fox, supra note 166, at 59.
170 Id.
171 See, e.g., Quan, supra note 62, at 1437–38.
172 Id. at 1428–29.
173 Id.
174 Id. at 1429.
175 Id. at 1429–30.
biological left at a crime scene is analogous to analyzing a fingerprint at a crime scene. The findings about phenotype and fingerprint whorls are not judgments in general about any group of persons. Both phenotype findings and fingerprint analyses are simply evidence at the scene, and, frankly, are much less prone to be the product of racial profiling, racism, or racial discrimination than eyewitness accounts. DNA phenotyping is not a value judgment and is not racial profiling; DNA phenotyping is simply a scientific finding objectively based on evidence left at the crime scene.

C. Objection: DNA Phenotyping Violates the Subject’s Right to Privacy

The third oft-noted argument against DNA phenotyping involves the potential privacy issues that may arise from investigating genetic traits discernible from DNA. Some fear that the collection of DNA databases will essentially lead to a vast collection of “genetic social security numbers” and, eventually, not just perpetrators, but all citizens, will be forced to hand over DNA samples. That is really an argument separate from DNA phenotyping itself.

Opponents in this area argue that genetic markers can reveal a great deal of personal information about an individual, not just physical characteristics but also behavioral propensities such as smoking, stuttering, predisposition for homosexuality, propensity toward pedophilia, and disease predispositions. This last objection is key, but is easily obviated. If legislative or judicial restrictions only permit DNA phenotyping for externally visible characteristics, then these hidden and arguably private characteristics, predispositions, and propensities would never be assessed, let alone disclosed. Thus, the privacy concern is very real, but is easy to remedy. Perhaps another remedy would be to couple the requirement that DNA phenotyping be used only for EVCs with a requirement that the DNA information be destroyed once the identification is made since the DNA phenotyping has completed its purpose.

VIII. CONCLUSIONS AND RECOMMENDATIONS

DNA phenotyping is a scientific approach carrying immense investigative power. Each year, 100 or more new genetic tests are developed, with new phenotypic connections and gene interrelationships being

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177 Id. at 294.
178 See Koops and Schellekens, supra note 62, at 201 (arguing that forensic phenotyping should not be allowed for sensitive information like homosexuality and pedophilia).
179 Id. at 186.
discovered at a dizzying pace. It is not beyond reason to expect that, as scientists continue to unravel, index, and classify the interrelationships between coding portions of our DNA and externally visible characteristics in the coming years, we could one day find that DNA phenotyping can create a probabilistic, but quite accurate, “wanted poster” of an offender based only on genetic testing of a biological specimen left at a crime scene. Furthermore, it is conceivable that virtual “wanted poster” could include an artist’s rendering of the face, including pigmentation, hair color, hair texture, nose width, lip height, overall adult height, handedness, dimpling, and even fingerprints themselves. That is, DNA phenotyping, if carried deep enough into DNA, could one day even generate the offender’s fingerprint, or at least fingerprint categories, with no need for the offender to have even left a fingerprint at the scene.

DNA phenotyping certainly has its limits. It evokes some ethical concerns. It is probabilistic, and not deterministic. Most externally visible characteristics are the product of the interactions of multiple areas of DNA rather than a single area, and therefore are challenging to determine. DNA phenotyping requires a substantial unknown sample from the crime scene. Mixtures and degraded samples are very difficult to interpret using DNA phenotyping. But all of that notwithstanding, the investigative power of DNA phenotyping is obvious and substantial, and most current concerns can and will be resolved by scientific advances and carefully crafted legislative enactments, judicial decisions, and laboratory protocols.

180 See supra text accompanying notes 44–45 (explaining the number of new genetic tests being created each year).
181 See supra text accompanying note 10 (stating that one day an artist’s rendering could be created from DNA evidence).
182 See supra Part II (setting forth the physical characteristics that can be determined by DNA phenotyping).
183 See supra Part VII (explaining the objections to the forensic use of DNA phenotyping).
184 See supra Part II, Table 1 (setting forth the difficulties of accurately predicting externally visible characteristics).
185 See Stephen J. Chanock et al., Replicating Genotype-Phenotype Associations, 447 Nature 655, 655 (2007) (“Small sample size is a frequent problem and can result in insufficient power to detect minor contributions of one or more alleles. Similarly, small sample sizes can provide imprecise or incorrect estimates of the magnitude of the observed effects.”).
186 Bruce Budowle & Angela van Daal, Forensically Relevant SNP Classes, 44 Biotechniques 603, 604 (2008); see also Walsh et al., Developmental Validation, supra note 73, at 467–68 (acknowledging the challenges associated with phenotyping degraded samples and mixtures).
187 See Claus Børsting et al., Application of SNPs in Forensic Casework, in Molecular Forensics 91, 98–99 (Ralph Rapley & David Whitehouse eds., 2007).
This article is intended as a call to action on several fronts. Minnesota’s crime laboratories should continue to be at the forefront of DNA science and develop a command of DNA phenotyping science and methods. Minnesota’s prosecutors and criminal investigators should inform themselves about DNA phenotyping techniques, strengths, and weaknesses, and seek solid cases in which to apply those techniques. Minnesota’s defense attorneys should study the science and prepare for the coming litigation.

As a final word, legislative and judicial leaders in Minnesota should consider the science, the power, the ethics, and the future of DNA phenotyping, and consider ways to allow proper use of this powerful tool, while also restricting improper uses. At a minimum, those leaders should consider the following factors: (1) DNA phenotyping is about probabilities and propensities, and thus is substantially different from DNA genotyping; (2) since DNA phenotyping is probabilistic, its forensic use should likely be limited to the investigative phase only, with admissibility of DNA phenotyping evidence at trial precluded; (3) certainly in early DNA phenotyping efforts, forensic uses should be limited to assessing only externally visible characteristics; (4) destroying the sample after phenotyping is completed will limit the potential for improper use of those samples later; (5) it may be wise to legislatively require that no one can perform DNA phenotyping on DNA samples that were collected for genotyping; and (6) it may be wise to preclude any DNA phenotyping use of samples already stored in DNA genotyping laboratories or cataloged in DNA databases.

The investigative power of DNA phenotyping is already profound and will explode in the coming years. Minnesota’s leaders should act now to ensure that use of this powerful tool is permitted but appropriately circumscribed.

human phenotypes can become sufficiently accurate to be used in forensic investigations.

Id. 188 See supra Part VI (setting forth the legislative and judicial developments in Minnesota law regarding DNA phenotyping).