PRB 08-29E

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NEW FRONTIERS IN FORENSIC DNA ANALYSIS: INTERNATIONAL PRACTICES AND IMPLICATIONS FOR CANADA

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3 March 2009

PARLIAMENTARY INFORMATION AND RESEARCH SERVICE
SERVICE D'INFORMATION ET DE RECHERCHE PARLEMENTAIRES

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INTRODUCTION

DNA(1) evidence has been used in criminal investigations since 1986; it was first used in Canada in 1988.(2) In the two decades since, DNA identification has become an integral part of the work carried out at forensic science laboratories across the country. The use of DNA identification was further expanded in 2000 with the establishment of the National DNA Data Bank, which allows investigators to rapidly screen DNA evidence against the DNA records of thousands of previously convicted criminals and evidence from other crimes.

This expansion of DNA forensic applications is the result of a number of advances in analysis technologies. Some of the changes have improved the efficiency of forensic DNA analysis – for example, robotic machines can now analyze hundreds of DNA samples at once – without significantly altering its applications outside the laboratory. However, other advances have made new applications for forensic DNA analysis possible. For instance, methods that can analyze microscopic traces of DNA can be used in different types of investigations, not in investigations of violent or sexual offences alone, the original focus of DNA analysis.

Genetic research is evolving, and current technologies used in forensic DNA analysis are almost certain to be altered by future scientific advances. Furthermore, changes in legal restrictions and social attitudes regarding the acceptable uses of genetic information can

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(1) DNA (deoxyribononucleic acid) is a long, double-stranded molecule that looks like a twisted rope ladder or double helix. It is the fundamental building block for each person's entire genetic makeup, and it is found in virtually every tissue in the human body. The DNA in a person's blood is the same as the DNA in his or her skin cells, saliva, and hair roots. With the exception of identical twins, each person's DNA is unique. This information has been adapted from material on the National DNA Data Bank website, at http://www.nddb-bndg.org/main_e.htm.

(2) Marie Lussier, "Tailoring the Rules of Admissibility: Genes and Canadian Criminal Law," *The Canadian Bar Review*, Vol. 71, June 1992, pp. 319–56.

change restrictions on the use of forensic DNA analysis. This paper examines three areas in which new DNA investigation methods are already changing the application of forensic DNA analysis internationally, or are likely to do so in the near future: (1) new analysis methods for comparing degraded DNA samples, (2) DNA database searches that identify suspects by their genetic similarities to relatives, and (3) analysis methods which could generate a physical description of a suspect based on DNA evidence. For each issue, the factors which would affect adoption of the new methods in Canada are discussed, with consideration of their potential impacts.

BACKGROUND: THE NATIONAL DNA DATA BANK

A. Legislative Framework

Analysis of crime scene DNA evidence on its own cannot identify the person from whom it originates; instead, it must be matched against a second, reference sample that is known to have originated from that person. In some cases, a suspect in a crime may volunteer a DNA sample to prove his or her innocence by confirming that it does not match the evidence. Often, however, a reference DNA sample is collected without consent. In the early years of forensic DNA analysis in Canada (1988–1995), a number of court decisions affirmed that forcibly taking bodily samples would usually be considered an "unreasonable search or seizure" in contravention of section 8 of the *Canadian Charter of Rights and Freedoms*, unless there was clear legislative authority for the collection.(3)

Parallel legislative frameworks now provide two types of authorizations for the collection of reference DNA samples for forensic purposes. The first type, DNA warrants, was established by amendments to the *Criminal Code* passed in 1995. A DNA warrant allows the collection of a DNA sample from an individual accused or suspected of a specific crime from which DNA evidence has been obtained. The second, collection orders for the National DNA Data Bank, was established by the *DNA Identification Act* (passed in 1998, in force since 2000). Collection orders authorize the collection of DNA from offenders after sentencing, for rapid comparison against evidence in ongoing investigations, or for future consideration. The use of

(3) For more information, see Jane M. Allain, *Forensic DNA Testing: Legal Background to Bill C-104*, BP-405E, Research Branch, Library of Parliament, Ottawa, August 1995.

both DNA warrants and DNA data bank collection orders is restricted to a specified list of designated offences,[4] there is judicial oversight in both cases, and there are legislated restrictions on the use of the resulting DNA samples and information.

The National DNA Data Bank consists of two parallel databases of DNA information, the Convicted Offenders Index and the Crime Scene Index. The Convicted Offenders Index is based on samples collected by court order from individuals found by a court to have committed a designated offence.[5] The Crime Scene Index contains information derived from biological evidence collected during investigations of designated offences. When new information is added to either database, it is compared against the other in order to identify matches; a match between crime scene information and offender information indicates a likely suspect for the crime, while a match between two crime scenes indicates that the same offender was involved in both crimes. A match between two offender entries is also possible: it indicates either identical twins or two sets of information erroneously entered for the same person.

As the Convicted Offenders Index only contains information on individuals found by a court to have committed a designated offence, a person's information must be removed if he or she is acquitted on appeal. In the case of a person absolutely or conditionally discharged for the offence,[6] the information is removed at the same time as other records are removed from criminal records databases, which is either one year (absolute discharge) or three years (conditional discharge) after the court decision.

The data bank is operated by the Royal Canadian Mounted Police (RCMP) and has its own laboratory in Ottawa where samples for the Convicted Offender Index are analyzed. Samples for the Crime Scene Index are analyzed by forensic laboratories operated by the RCMP as well as by the Ontario and Quebec governments.

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(4) As defined in section 487.04 of the *Criminal Code*. The list of offences is divided into "primary" and "secondary" designated offences, which are subject to different procedures for DNA collection orders.

(5) Specifically, this includes anyone convicted or discharged under the *Criminal Code*, found guilty under the *Youth Criminal Justice Act* or *Young Offenders Act*, or found not criminally responsible on account of a mental disorder.

(6) Under section 730 of the *Criminal Code*, after a person has pled guilty or been found guilty, a court "may, if it considers it to be in the best interests of the accused and not contrary to the public interest, instead of convicting the accused, by order direct that the accused be discharged absolutely or on the conditions prescribed in a probation order."

B. DNA Identification Technology in Use

DNA is the molecular basis of genetic information and is contained in the cells of living organisms. The totality of genetic information in an organism's DNA is referred to as its genome; however, the genome contains much more information than is necessary for DNA identification, and complete sequencing of DNA samples is unnecessary for this purpose. Instead, DNA samples collected for forensic reasons are compared through the generation of DNA profiles, digital files that summarize selected elements of genetic information.(7)

Human DNA is organized into structures called chromosomes which are located in the nucleus of each cell. Humans have 23 pairs of chromosomes, including a pair of sex chromosomes: either two X chromosomes (females) or an X and a Y chromosome (male). One chromosome in each pair is inherited from each parent. The organizational structures of the chromosomes in each pair (with the exception of the dissimilar X–Y pair in males) match identifiable regions of DNA, which have particular functions or properties. Nonetheless, the information encoded in each region of DNA – defined by the molecular sequence of the DNA molecule – may differ between the two chromosomes in a pair. It always differs between the same chromosome in two different people, except in identical twins.

The vast majority of the genetic information in the human genome, much of which is essential for life, is the same from one person to the next. However, certain regions of chromosomes exhibit high levels of variation among individuals, and these regions are used as DNA "markers" to create a DNA profile.

The analysis method most commonly used in forensic DNA work today for the creation of DNA profiles – including those created at the National DNA Data Bank – employs markers based on short tandem repeat (STR) DNA. The repeated DNA sequences in STR segments have naturally mutated over millennia, increasing or decreasing the number of repeats. This results in two properties of STR segments that make them very useful as DNA identification markers: (1) there are many possible variations of these segments in the human population, and (2) the variations that are present in a given DNA sample can be easily identified using techniques which determine the length of a selected DNA segment.

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(7) For more information, see Thomas Curran, *Forensic DNA Analysis: Technology and Application*, BP-443E, Parliamentary Information and Research Service, Library of Parliament, September 1997.

The National DNA Data Bank uses profiles containing 13 different STR markers, each with 8 to 31 known variations.(8) A DNA marker which differentiates between the X and Y sex chromosomes is also analyzed. Analysis of each marker provides two distinct pieces of information because each person has one version of each of the two chromosomes, one from each parent, and therefore two versions of the DNA marker. The profile therefore contains 26 identification elements (13 markers, each on two chromosomes) plus an indication of whether the person is genetically male or female.

A profile with this many markers is highly unlikely to be the same in any two people other than identical twins; the probability of a random match is in the order of one in billions or even one in trillions.(9) Despite this high specificity, the profile can be described very concisely by simply listing the lengths of the variations found for each of the 13 markers.

The laboratory at the National DNA Data Bank uses robotic equipment to analyze many DNA samples at once in a controlled and consistent manner.(10) The samples themselves (usually blood, but sometimes hair samples or mouth swabs) are collected on paper cards impregnated with preservative chemicals. This method allows the dried samples to be preserved indefinitely without the need for refrigeration. Analysis procedures for crime scene samples are much more varied and labour intensive, reflecting the greater diversity in sample size, type and quality.

ADVANCES IN DNA IDENTIFICATION TECHNOLOGY

A. New Technologies and Fields of Research

The usefulness of a DNA identification method for forensic work depends on:

- the ability to distinguish between different persons with a low probability of a random match (i.e., its “discriminatory power”);
- the ability to generate a DNA profile from small or degraded biological samples; and
- the ability to generate a DNA profile quickly and inexpensively.

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(8) Cecilia Hageman, Derrill Prevett and Wayne Murray, *DNA Handbook*, Butterworths, Toronto, 2002, pp. 32–4.

(9) John Butler, “Background Information,” *Short Tandem Repeat DNA Internet DataBase (STRBase), STR Training Materials*, National Institutes of Science and Technology (United States), http://www.cstl.nist.gov/div831/strbase/training.htm.

(10) Joanna Kerr, “Building the Future of DNA Technology: RCMP’s DNA Data Bank Sets a World Standard,” *RCMP Gazette*, Vol. 62, No. 5/6, 2000, pp. 21–8.

In the mid- to late 1990s, forensic laboratories adopted the STR method in place of previously established methods which had poorer performance in one or more of these measures. STR is highly discriminative, with a low probability of a random match, and can be used to analyze very small samples in only a few days.(11) However, in some cases STR analysis will not generate a profile, such as when a sample is badly degraded or too small to analyze. Furthermore, although current STR analysis methods are much faster than older technologies, high demand for DNA analysis has made greater time and cost reductions an important priority for forensic laboratories.

A possible improvement being pursued is the use of miniSTRs.(12) As the name suggests, the technique is essentially the same as that employed in identifying STR DNA, except that smaller DNA segments are used. This property is beneficial when analyzing degraded DNA, where the strands have been broken into short pieces. If shortened DNA regions are used in the analysis, then degraded DNA is still useful. MiniSTR markers can be analyzed concurrently with the usual STR markers.

Other new methods analyze different types of genetic variations. Variations in repeat regions of the genome are only one way in which DNA can differ from person to person. Another difference is a variation in a single element of the molecular code – a single nucleotide polymorphism, or SNP (usually pronounced “snip”). It is estimated that there are 3 million SNPs in the human genome, not including rare mutations found in less than 1% of the population.(13) However, because there are usually only two variations found at each SNP location, a single SNP does not provide sufficient information to identify an individual. As a result, proposed forensic identification tests involving SNPs would use 50 or more SNPs to create a unique DNA profile.

One potential benefit of SNPs is the possibility that they be analyzed using even shorter pieces of DNA than miniSTRs. It is also possible that they could be analyzed using faster or more affordable methods, because there would be no need to separate DNA segments

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(11) Conventional STR analyzes samples as small as 1 nanogram of DNA (obtainable from approximately 20 nanolitres of blood, or a droplet about one-third of a millimetre in diameter), Applied Biosystems, *AmpFlSTR® Profiler Plus® PCR Amplification Kit: User’s Manual*, 2006, p. 3-3 and 12-10).

(12) National Institute of Standards and Technology, “miniSTRs (Reduced-size STR Amplicons),” http://www.cstl.nist.gov/div831/strbase/miniSTR.htm.

(13) United States Department of Energy, The Human Genome Project, “SNP Fact Sheet,” http://www.ornl.gov/sci/techresources/Human_Genome/faq/snps.shtml.

by length. However, there is as yet no scientific consensus on the best methods to use for this type of analysis. Methods being developed for other fields of genetic research are not necessarily suitable for use with small or degraded DNA samples.(14) Furthermore, the analysis of mixtures of DNA originating from more than one individual (common in forensic work) is more complicated for SNPs than for STRs, due to the reduced potential for variation at each marker. European and North American forensic DNA researchers have suggested that, overall, SNP methods are not as likely as miniSTR methods to be of practical forensic use in the near future.(15) Nonetheless, research into SNP identification methods is ongoing.(16)

The analysis of mitochondrial DNA is a well-established application of SNP methods. DNA contained in the mitochondria (the energy-producing compartments of each cell) is distinct from the chromosomal DNA contained in the cellular nucleus which has been the subject of discussion thus far. Each nucleus has only one set of nuclear chromosomes per cell, 26 pairs, but there are hundreds or thousands of identical copies of the mitochondrial DNA, which makes mitochondrial DNA markers easier to detect.(17) Mitochondrial DNA analysis may therefore be used when the sample is small or degraded. It can also be used to analyze DNA from hair shafts (as opposed to hair roots), which do not have nuclear DNA.(18)

An important property of mitochondrial DNA is its exclusively maternal origin, so that all maternally related individuals have the same mitochondrial genome. This attribute can be useful – such as when identifying human remains by comparison with the DNA of a suspected family member – but it is not possible to identify a person from mitochondrial DNA alone.

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(14) Peter Gill et al. "An assessment of whether SNPs will replace STRs in national DNA databases – Joint considerations of the DNA working group of the European Network of Forensic Science Institutes (ENFSI) and the Scientific Working Group on DNA Analysis Methods (SWGDAM)," Correspondence, *Science & Justice*, Vol. 44, Issue 1, 2004, pp. 51–3, http://www.cstl.nist.gov/div831/strbase/SNP.htm.

(15) Gill et al. (2004) and L.A. Dixon et al., "Analysis of artificially degraded DNA using STRs and SNPs – results of a collaborative European (EDNAP) exercise," *Forensic Science International*, Vol. 164, Issue 1, 1 December 2006, pp. 33–44.

(16) See, for example, the website of the SNPforID Project, a consortium of European forensic research groups, at http://www.snpforid.org/; also, A.J. Pakstis et al., "Candidate SNPs for a Universal Individual Identification Panel," *Human Genetics*, Vol. 121, 2007, pp. 305–17.

(17) Hageman, Prevett and Murray (2002), pp.7–8.

(18) Henry C. Lee and Frank Tirnady, *Blood evidence: How DNA is revolutionizing the way we solve crimes*, Perseus Publishing, Cambridge, MA, 2003, pp. 88–90; and, Hageman, Prevett and Murray (2002), p. 23.

B. International Experience

Adoption of a novel analysis method for use in a DNA data bank affects all laboratories and all investigations contributing to the data bank. If the new system is different from the old one (i.e., if it does not analyze the same markers), then stored biological samples will have to be re-analyzed, if available. This situation occurred in a number of American states in the 1990s when the US federal government mandated the use of the standardized STR profile system, replacing older technologies used by some early state DNA data banks.(19) If re-analysis is not possible (e.g., because samples are not available), then the new and old systems would have to be operated in parallel, and the usefulness of the new system would be reduced.

In contrast, new markers can be added to an established system without requiring mass re-analysis. For example, in the United Kingdom a former six-marker STR system was expanded to include four additional STR markers, but samples are re-analyzed only if there is a match to the six-marker profile.(20)

More recently, there has been some action internationally to add new types of DNA markers to established STR-based DNA data banks. In the United States, the Federal Bureau of Investigation (FBI) now uses mitochondrial DNA markers for profiles of missing persons and unidentified remains due to the markers' unique properties, described above, but it does not employ them for criminal investigation data banks.(21) In Europe, an advisory group tasked with improving harmonization of forensic DNA methods among countries has recommended the adoption of at least three miniSTR markers.(22) This would improve the analysis of degraded DNA as well as increase the number of markers in common among the different profiles used by member countries.

Not all international efforts to adopt advanced DNA analysis methods have proceeded without difficulty. In the United Kingdom, the Forensic Science Service (a United Kingdom government-owned company) developed and promoted a version of STR (known as low copy number testing) designed to analyze samples as small as a few cells, such as might be found in a fingerprint.(23) However, public prosecution services in the United Kingdom

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(19) Ibid., p. 172.

(20) Parliamentary Office of Science and Technology (United Kingdom), "The National DNA Database," *Postnote*, No. 258, February 2006.

(21) President's DNA Initiative (United States), "Types of Profiles in the Database," http://www.dna.gov/uses/database/types.

(22) The European DNA Profiling Group (EDNAP), http://www.isfg.org/ednap/ednap.htm.

(23) The Forensic Science Service Ltd., "DNA Low Copy Number," Fact Sheet 6, 5 December 2005, http://www.forensic.gov.uk/pdf/company/foi/publication-scheme/communications/DNA_Low_Copy_Number_000.pdf.

suspended the use of the technique for a short while after it was criticized by a judge in a high profile case in Northern Ireland.(24) The United Kingdom had been one of only a few jurisdictions which used the method.(25)

C. The Canadian Context

Changing technologies were anticipated in the drafting of the *DNA Identification Act*. As a result, DNA samples are preserved following analysis; under section 10 of the Act, they may be re-analyzed if justified by "significant technological advances," but may not be used for any other purpose.

Any analysis method, including the new methods described above, may be used in Canada during investigations, and could therefore be adopted for particular cases where the conventional STR method fails to obtain results from degraded DNA evidence. However, the results in these cases could only be compared to reference samples collected with a DNA warrant or from volunteers and analyzed with the same methods, and not against data bank profiles.

D. Potential Impact

It is almost inevitable that the forensic identification methods used for the National DNA Data Bank will be updated eventually. Decisions to implement new methods will likely be affected by decisions in other jurisdictions. Currently, Canada uses the same 13 DNA markers as the United States; seven of these markers are used by Interpol as an international standard. If either the US or Interpol adopted new markers, it would be advantageous for Canada to adopt them as well, in order to maximize the effectiveness of international criminal investigations.

Such a change would have resource implications as well. A change in analysis methods would impose transition costs on forensic laboratories and on the National DNA Data Bank, particularly if large numbers of stored samples required re-analysis. However, these costs could potentially be offset over time if the new method offered significant operational savings.

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(24) Gordon Rayner, "The flaws in the case," *The Daily Telegraph* (London, UK), 21 December 2007, and Christopher Hope, "Nickell review after Omagh trial collapse," *The Daily Telegraph*, 22 December 2007.

(25) Hope (2007).

FAMILIAL SEARCHING OF DNA DATA BANKS

A. Using the Hereditary Information in a DNA Profile

The commonly accepted use of DNA data banks is to identify a DNA profile that exactly matches a profile generated from evidence related to a crime. Familial searching (also known as "kinship searching") extends the reach of the data bank by searching for a DNA profile that has a high probability of belonging to a close relative of the person who left the crime scene evidence. If any such matches are found, relatives of the profiled persons are then investigated to identify potential suspects in the crime.

Familial searching is possible because of the high level of variation contained in the set of genetic markers used in a DNA profile. It is extremely unlikely that two unrelated people would have exactly the same profile and relatively unlikely that they would have more than a few elements of the profile in common. However, two closely related people are likely to have many common DNA markers. A parent shares one marker in every pair with each child; full siblings also share, on average, half of the DNA profile elements.

The theory behind familial searches is well established, and is similar to that used in paternity testing. The technique is used to identify victims of mass disasters, and the RCMP has developed software that assesses the likelihood that two DNA profiles belong to related individuals.(26) Researchers in the United States are investigating the possibility of using familial searching as a means to improve the effectiveness of DNA data banks of missing persons and unidentified human remains.(27)

B. International Experience

In April 2004, a man in the United Kingdom became the first person to be convicted after having been identified by using a family member's DNA in a data bank.(28) Familial searching is now established practice at the National DNA Database in the United

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(26) B. Leclair, C.J. Fregeau, K.L. Bowen, and R.M. Fourney, "Enhanced kinship analysis and STR-based DNA typing for human identification in mass fatality incidents: The Swissair Flight 111 disaster," *Journal of Forensic Sciences*, Vol. 49, Issue 5, paper # JFS2003311, 1 September 2004.

(27) Federal Bureau of Investigation (United States), "CODIS – The Future," http://www.fbi.gov/hq/lab/html/codis4.htm.

(28) "The sins of the fathers," *Economist*, Vol. 371, Issue 8372, 24 April 2004.

Kingdom, although it is currently used only for a limited number of serious crimes. Guidelines and advice to control the resulting investigations of family members and the potential release of sensitive information have been developed by the United Kingdom's Information Commissioner and a DNA operations advisory group.(29) Nonetheless, some sources have suggested that the United Kingdom government is considering expanding the use of the technique.(30) As of March 2006, familial searches had been used in 120 cases in the United Kingdom. In 12 of these cases, charges had been laid against a suspect identified through a relative's DNA profile (7 convictions and 5 cases in progress at that time); in an additional three cases, a suspect was identified, but was deceased.(31)

In the United States, the FBI operates a national database of DNA profiles, but legal frameworks surrounding the collection and use of DNA samples vary significantly from state to state. The FBI's policy is that it will assess each request to release the identity of an individual whose profile partially matches a crime scene profile.(32) Whether investigators search for and use these partial matches depends on state law and laboratory resources.

At the state level, California has recently adopted a policy requiring the state's crime lab to report any partial matches discovered during a search of the state's database, and to statistically analyze the probability of a relationship between the person who left the crime scene sample and the person profiled in the database.(33) More complex search methods may also be used if no partial matches are detected in the original search. At least two other states (Colorado and Massachusetts) are examining the possibility of similar policies.(34) In contrast, the state of Maryland has recently passed a law banning familial searching.(35)

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(29) United Kingdom, National DNA Database [NDNAD], *Annual Report 2005–2006*, September 2006, pp. 12 and 20.

(30) Patrick Hennessy and Ben Leapman, "Ministers plan sweeping new 'Big Brother' police powers: Memo reveals scheme for DNA checks, scanning mail and tracking travel passes," *The Daily Telegraph* (London, UK), 4 February 2007.

(31) NDNAD (2006), p. 20.

(32) American Prosecutors Research Institute, "Catching Criminals by Investigating Profiles with Allelic Similarities," *Silent Witness* (newsletter), Vol. 10, No. 2, 2006, http://ndaa.org/publications/newsletters/silent_witness_volume_10_number_2_2006.html.

(33) Maura Dolan and Jason Felch, "California takes lead on DNA crime-fighting technique," *Los Angeles Times*, 26 April 2008.

(34) Ellen Nakashima, "From DNA of Family, a Tool to Make Arrests: Privacy Advocates Say the Emerging Practice Turns Relatives Into Genetic Informants," *The Washington Post*, 21 April 2008.

(35) Ibid.

C. The Canadian Context

Currently, familial searching of the DNA data bank is not permitted under the *DNA Identification Act*. Under the Act, the information from which an offender's identity can be determined (and therefore from which relatives' identities could be determined) may be transmitted only if there is an exact match between the offender's DNA profile and a crime scene profile. In the case of a questionable match (as might occur because of a mixed or degraded crime scene sample), identifying information is transmitted only if an exact match cannot be ruled out upon further analysis of the two profiles.(36) Nonetheless, since identical twins have the same DNA profiles, it is possible that a twin could be identified as a suspect based on a data bank match with the other twin's profile.(37)

Other features of the Canadian DNA data bank could deter the use of familial searching, despite the precedents in the United Kingdom and some American states. From a practical perspective, the size of the data bank, with less than 0.5% of Canadians profiled (compared to more than 5% in the United Kingdom), reduces the chance of a finding a family member. From a political perspective, using the Canadian Convicted Offenders Index to investigate individuals with no criminal background would be a significant policy change, one that might be difficult to implement. In contrast, in the United Kingdom the DNA database already contains profiles of innocent citizens. In England and Wales, DNA may be collected and entered in the data bank from anyone arrested and detained for a crime, even if they are released without charge or eventually acquitted.(38) Some American states (including California) also include profiles of suspects in their databases.(39)

Familial genetic similarities have been used to identify suspects in Canadian cases without relying on the data bank. For example, in the investigation of a 2002 murder in Alberta, partial matches between crime scene evidence and DNA samples given voluntarily by

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(36) *DNA Identification Act*, S.C. 1998, c. 37, s. 6.

(37) As of 31 March 2006 there were 48 pairs of identical twins profiled on the database. Royal Canadian Mounted Police, *National DNA Data Bank of Canada: Annual Report 2005–06*, p. 19.

(38) The practice of maintaining DNA profiles after charges have been dismissed was challenged before the European Court of Human Rights (in the cases of *S. and Michael Marper* v. *the United Kingdom*, case nos. 30562/04 and 30566/04), and on 4 December 2008, that court ruled that such a practice is a breach of human rights.

The collection and retention of DNA is more restricted in Scotland and Northern Ireland, but individuals charged but not convicted are still included in the national database; see NDNAD (2006) pp. 8–11.

(39) See the American Society of Law, Medicine and Ethics, *Survey of DNA Database Statutes*, http://www.aslme.org/dna_04/grid/index.php.

two individuals led investigators to suspect a close relative of the men who had submitted the samples. The son of one of the men was eventually convicted of the crime on the basis of an exact DNA profile match.(40)

Familial searching has been discussed in reports of the DNA Data Bank Advisory Committee, an independent body established to advise the RCMP Commissioner on matters related to the establishment and operation of the data bank. The committee's 2005–2006 annual report offered tentative support for the release of information where partial matches were detected in the course of normal searches, subject to "stringent operational procedures … to avoid intrusive practices."(41) In its 2006–2007 annual report, the committee recommended that the broader topic of familial searching "be discussed in a public forum where both the privacy rights of citizens as well as the right of the state to utilize this technology in the interests of the justice system can be discussed in some depth."(42) They suggested that the statutory parliamentary review of the *DNA Identification Act* could provide one such opportunity for discussion.(43)

D. Potential Impact

The benefit of using familial searches of DNA data banks is straightforward: it enables the identification of crime suspects when other investigative means have failed. This perspective has often been emphasized in British sources. For example, a newspaper report of a successful investigation into a "cold case" – which identified a serial rapist because his sister's DNA had been sampled after an arrest for impaired driving – declared that "the case represents the biggest success for familial profiling, which can trace criminals even if they have not been placed on the national DNA database."(44)

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(40) Karen Kleiss, "Convicted killer asks top court to review DNA case against him," *The Edmonton Journal*, 19 January 2008; and Karen Kleiss, "Supreme court won't allow killer to appeal," *The Edmonton Journal*, 28 March 2008.

(41) National DNA Data Bank Advisory Committee, 2005–2006 Annual Report. These comments were in response to questions in a "draft consultation document" which the Department of Justice had asked the Committee to review in preparation for the statutory parliamentary review of the *DNA Identification Act*.

(42) National DNA Data Bank Advisory Committee, 2006–2007 Annual Report.

(43) This review is required under section 13 of the Act, to begin five years after the Act came into force (i.e., by 30 June 2005). The Senate Standing Committee on Legal and Constitutional Affairs is scheduled to begin its review in March 2009.

(44) Paul Stokes, "Shoe rapist kept store of stilettos as trophies," *The Daily Telegraph* (London, UK), 18 July 2006.

The potential use of such searches nonetheless raises concerns about genetic privacy. Although there is some statistical evidence of familial trends of criminal behaviour,(45) using such connections as the basis for investigation would usually be controversial.

If Canadian legislation were changed to allow familial searching, it would also raise constitutional questions that have not yet been considered in legal challenges. In this scenario, the legislative provisions would permit the privacy invasion related to the use of one's DNA information. Relatives of convicted offenders (who in most cases would not have criminal records themselves) might find their personal information encoded in a government criminal-record database, increasing the probability of those people becoming the subjects of police investigations.

However, when assessing whether a seizure of bodily material infringes on a person's Charter rights, Canadian courts have repeatedly emphasized that the physical invasion of a properly performed DNA collection procedure is minor, and that the informational aspect of DNA overrides concern about the procedure.(46) The use of the DNA data bank to analyze family relationships would also bring into question the Supreme Court's conclusion that the DNA data bank is intended to be an identification tool only – to identify criminals who "have lost any reasonable expectation that their identity will remain secret from law enforcement authorities" – which was an important factor cited when dismissing a constitutional challenge.(47)

ANALYSIS OF DNA EVIDENCE TO DETERMINE PHYSICAL TRAITS

A. Scientific Potential Versus Technological Reality

Considerably more information is contained in a crime scene DNA sample than is currently analyzed for identification purposes. Theoretically, a more complex analysis of the evidence could generate a physical description of the person who is the source of the material.

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(45) Frederick R. Bieber, Charles H. Brenner and David Lazer, "Finding Criminals Through DNA of Their Relatives," *Science*, Vol. 312, 2 June 2006, pp. 1315–16.

(46) See, for example, *R.* v. *S.A.B.*, [2003] 2 S.C.R. 678, par. 47–49, or *R.* v. *Rodgers*, [2006] 1 S.C.R. 554, par. 39–40.

(47) *R.* v. *Rodgers*, par. 5 and 42.

Hair, eye and skin colour and physical build are all at least partially determined by genetic traits,(48) and could be determined from DNA samples. Such a "DNA-witness" description of a suspect could be available when eye witnesses are not, and would not be subject to the fallibilities of eye-witness descriptions.

However, there are currently only a limited number of DNA analysis methods available which can predict physical traits, and even these are not guaranteed to be accurate.(49) More common are DNA tests which predict a person's racial background as a combination of continental groupings (e.g., Sub-Saharan African, Indo-European, East Asian or Native American) by looking for DNA markers which are common in one group but rare in others.(50) These tests are marketed to individuals who wish to determine their own genealogical ancestry, but are also marketed to forensic scientists.(51)

The human genome is highly complex, and many apparently simple physical traits, such as skin or hair colour, are controlled by the interaction of numerous genes plus environmental factors. The DNA markers which are measured in genetic tests of racial background are not directly linked to physical traits that may be associated with the same racial groups. Furthermore, these tests are based on probabilities, and do not provide definitive results.

Because these tests are used primarily to screen suspects – and not as part of the evidence presented in court – information about the current extent of their use is not readily available.

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(48) See, for example, Wojciech Branicki et al., "Determination of Phenotype Associated SNPs in the MC1R Gene," *Journal of Forensic Sciences*, Vol. 52, Issue 2, March 2007, pp. 349–54 (regarding a genetic test for red hair colour); or Boonsri Dickinson, "Eye Color Explained," *Discover*, Vol. 28, Issue 3, March 2007, p. 16 (in which geneticist Rick Sturm discusses his work on eye colour pigmentation, saying, "There is no single gene for eye color, but the biggest effect is the OCA2 gene.").

(49) For example, a company which markets a forensic test for eye colour only promises 92% accuracy (i.e., there is an expectation of 1 error in every 12 tests): DNAprint Genomics, "Products and Services: Forensics," http://www.dnaprint.com/welcome/productsandservices/forensics/.

(50) These tests are based on published scientific studies of DNA traits and population patterns, such as Noah A. Rosenberg et al., "Genetic Structure of Human Populations," *Science*, Vol. 298, Issue 5602, 20 December 2002, p. 2381; or Luciana Bastos-Rodrigues et al., "The Genetic Structure of Human Populations Studied Through Short Insertion-Deletion Polymorphisms," *Annals of Human Genetics*, Vol. 70, Issue 5, September 2006, pp. 658–65.

(51) DNAprint Genomics.

B. International Experience

A few cases have been reported in the United States where racial analysis of DNA crime scene evidence or of unidentified murder victims advanced a criminal investigation.(52) Although the resulting information about racial background was not sufficient to identify a particular suspect, it helped investigators assess the significance of witness descriptions or other tips.

C. The Canadian Context

There are no legislative or regulatory requirements that identify or limit the types of DNA analyses which may be used for forensic purposes in Canada. This situation is in contrast to the practice in some other countries. For example, in France, statutory law states that only "non-coding" DNA(53) can be analyzed for that country's national data bank; the specific markers which may be used are set by regulation.(54)

The DNA markers that are used for the National DNA Data Bank – and for most analyses of DNA evidence – are not connected with any recognizable characteristic other than sex. However, there have been reports that a number of Canadian police forces, including the RCMP, have used the services of a company which performs racial analysis of DNA found at crime scenes.(55)

D. Potential Impact

As scientific understanding of the genome increases, and as analytical methods improve, more genetic tests for physical characteristics are likely to be developed, and these tests will become more reliable and more affordable. Given the importance of physical descriptions to criminal investigations, there will likely be a corresponding increase in the desire to use these methods to analyze forensic DNA evidence. One concern that has been raised about such

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(52) Jessica Sachs, "DNA and a New Kind of Racial Profiling," *Popular Science*, Vol. 263, Issue 6, p. 16, December 2003; Richard Willing, "DNA tests offer clues to suspect's race," *USA Today.com*, 16 August 2005, http://www.usatoday.com/news/nation/2005-08-16-dna_x.htm.

(53) "Non-coding" DNA specifically refers to DNA sequences that do not contain information for the construction of protein products. The French law does make an exception for the use of a sex marker.

(54) France, *Code de procédure pénale*, ss. 706–54 (legislation) and A38 (regulation).

(55) Carolyn Abraham, "Molecular eyewitness: DNA gets a human face; Controversial crime-scene test smacks of racial profiling, critics say," *The Globe and Mail*, 25 June 2005.

methods is that the results could be used to justify "DNA dragnets" – the collection of DNA samples from large groups of people – based on physical descriptions or race, whether or not there is any other reason to suspect them of the crime.(56)

DNA tests based on racial background are likely to provoke greater controversy than those that assess more objective physical characteristics, such as eye or hair colour. Already, the popularity of racial analysis tests for genealogy has raised concerns that it will reinforce racial stereotypes or bias by emphasizing the differences between populations of different backgrounds.(57) Other concerns about racial tests are specific to forensic contexts: the results may not be useful as a physical description of a person of mixed racial background, or investigators may incorrectly exclude a suspect who does not appear to match a description.(58) Furthermore, the benefit to police (from the elimination of suspects who do not match the description) would statistically be greatest when the identified racial group forms a minority in the community, and therefore investigations that use racial tests could disproportionately focus on minority communities.(59)

The potential benefits of using DNA analysis methods that identify physical characteristics are restricted to the analysis of unknown biological samples. The physical descriptions of individuals profiled in the National DNA Data Bank are already recorded in other criminal records. Furthermore, any proposal to use such analysis methods for data bank profiles would mark a significant departure from current policy, which has highlighted the use of "anonymous pieces of DNA" as an important privacy protection measure.(60) It could also provoke new challenges of the data bank's constitutionality and the Supreme Court's assessment of the DNA data bank as an identification tool only.(61)

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(56) Willing (2005) and Sachs (2003). Note that in Canada, such "dragnets" could only include DNA samples given voluntarily, although experience has shown that very few people will refuse to give DNA when asked to help solve a serious crime. For example, less than 1% of approximately 1,000 neighbours refused to give DNA when requested during the investigation of the 2003 murder of 10-year-old Holly Jones, according to Toronto police: Melissa Leong, "Slain girl helped police find killer," *National Post*, 22 February 2005.

(57) See, for example, Amy Harmon, "In DNA Era, New Worries about Prejudice," *The New York Times*, 11 November 2007; or Margaret Munro, "Ancestry too complex for DNA test; Report says web tests can't link you to Genghis Khan," *Calgary Herald*, 19 October 2007.

(58) Pilar N. Ossorio, "About Face: Forensic Genetic Testing for Race and Visible Traits," *Journal of Law, Medicine & Ethics*, Summer 2006, pp. 277–92.

(59) Ibid.

(60) National DNA Data Bank, "Privacy and Security," http://www.nddb-bndg.org/pri_secu_e.htm.

(61) *R.* v. *Rodgers*, par. 5 and 42.

CONCLUSION

Forensic DNA technology has undergone significant advances since its introduction in the 1980s, and its applications in Canadian criminal law have also changed over that period. Because the technology is still developing, future advances and changes are likely to occur as well.

New analysis methods and DNA markers to compare DNA evidence with reference samples from data banks are being investigated in many jurisdictions. Whether they are adopted in Canada will likely depend on the degree to which they increase the ability to successfully analyze diverse types of DNA evidence, on their cost compared to existing methods, on the costs of transitioning to a new system, and on the actions of other jurisdictions, such as the United States and Europe.

Familial searching of DNA databanks is used in the United Kingdom and some American states, but it is not permissible in Canada under the *DNA Identification Act*. Furthermore, even if the Act were amended to permit familial searching, the practice might be considered unconstitutional under the *Canadian Charter of Rights and Freedoms*.

The analysis of an unknown DNA sample to determine the physical traits of its source is an option currently limited by the available technology. However, as more reliable analysis methods emerge, this approach could provide descriptive information to identify suspects from DNA evidence when no match with the DNA data bank has been found.