



DNA

The 21st Century Detective

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1. Introduction

South Africa has one of the highest murder rates and lowest conviction rates in the world.¹ Criminals are not held accountable for their actions in a society that has become desensitised to the traumatic effects of crime on its people, economy and general morale. Murder, rape and violent crime have, sadly, become commonplace and every person living in South Africa has either been exposed to or affected by crime in some manner. The tenacious citizens of South Africa have braced themselves against this blight and searched for novel ways to prevail over crime.

DNA profiling is a technologically advanced method of tackling crime and has aptly been called the 21st Century Detective. This paper explores the successful international use of DNA profiling as a crime-fighting tool and explores the potential benefits of expanding and developing the National DNA Database of South Africa (NDDSA) to ensure accountability and deterrence amongst its criminal population. It reflects upon the many challenges South Africans face in ensuring that the expansion of the NDDSA is successful. It considers the societal issues raised by the use of DNA in the legislative framework recently proposed by Parliament.

The current situation in South Africa is considered against a backdrop of the work of The DNA Project, an NGO raising awareness of the need to expand and develop the NDDSA as a major crime fighting tool. Extensive 'DNA expansion programmes' in countries such as the UK and USA are evaluated in terms of the benefits accrued from their use of DNA databases for criminal intelligence purposes. It is hoped that such a DNA expansion programme in South Africa will effectively combat the scourge of crime plaguing this country and act as a crime deterrent.

2. DNA profiling

What is DNA?

DNA stands for deoxyribonucleic acid. This is the name of the chemical which is found in virtually every cell in the human body and which carries genetic information from one generation to the next. As with our fingerprints, humans each have a unique DNA signature that remains unchanged throughout our

A DNA profile is simply a unique set of numbers obtained from a person's DNA that acts as a personal 'identification number'.

lives. Whereas fingerprints can only be found at a crime scene, if a person touches a suitable surface with bare fingers, DNA can be extracted from hairs, skin cells, blood, fragments of bone or teeth, as well as from body fluids left after a crime. DNA testing, generally called DNA profiling, takes advantage of the fact that, with the

exception of identical twins, the genetic material of each person is unique and is an omnipresent residue that trails us wherever we go. A DNA profile is simply a unique set of numbers obtained from a person's DNA that acts

as a personal 'identification number'. In cases where fingerprints are not found, DNA profiling may provide information as to who was present at a crime scene. These physical properties of DNA have made it a critical tool in fighting crime.

In South Africa, the courts have defined DNA profiling as:

a relatively new type of testing that may be performed on a wide range of bodily samples, including blood, with a view to proving guilt, establishing innocence or proving relationships. The test, a complex one, is based upon the scientific thesis that all individuals, save for identical twins, possess a unique genetic code held in the 46 chromosomes which are made up of the complex chemical which is DNA.²

Throughout the world, DNA profiling provides evidence that may be used to convict criminals. It also enables forensic scientists to re-examine old cases previously closed due to lack of evidence. Cold cases have been reopened because DNA profiles can now be extracted from stored samples and evidence. These cases have not always been solved, but the use of DNA evidence has allowed many convicted prisoners to be set free when DNA tests proved their innocence.

This technique was also indispensable in identifying victims of the bombing of the World Trade Center on 11 September 2001 and the identification of bodies after the tsunami on 26 December 2004, as well as of apartheid activists buried alone or in mass graves.

DNA profiling is used to show how people are related. In addition, ancient skeletal remains can now provide information that can lead to the reconstruction of historical events.

Behind the scenes: The science of DNA profiling

All DNA consists of two long chains of sub-units, twisted around each other to form a double helix. The sub-units of each strand consist of nucleotides, each of which contains any one of four chemical constituents, attached to a phosphorylated molecule of the 5-carbon sugar deoxyribose. The four nucleotides in DNA are adenine (A), thymine (T), guanine (G) and cytosine

(C). The specific sequence of nucleotides in the long chain of DNA identifies it as, for example, human, canine or a particular plant species. However, individuals within each group also have their own unique DNA sequences at other locations. At a chromosomal location where individual people differ, one person may have the sequence GATCGT and another GAACGT. These differences in nucleotide sequences allow individuals within a species to be identified.

Case study: The first high-profile DNA forensic cases

The first high-profile DNA forensic case involved the rape and murder of two 15-year-old high school pupils in a small village in Britain in 1983 and 1986. In the first case, a semen sample had been taken from the victim's body and was found to belong to a person with type A blood and an enzyme profile that matched only ten percent of males. With no other leads or evidence, the case was left open. The police linked the two cases as they believed that the modus operandi of the second attack matched that of the first, and semen samples had revealed the same blood type. A worker at a local psychiatric institution was arrested for both offences and subsequently confessed to one of the murders. The police sent samples of both the victims' and the suspect's blood to Sir Alec Jeffreys' molecular laboratory at Leicester University, where Jeffreys had recently developed a new technique called 'DNA profiling'. Using this technique, DNA tests revealed that the DNA of the suspect was different to that of the rapist/murderer, who had left semen at both crime scenes. This conclusively proved that both girls were killed by the same man, who was not the suspect previously arrested. The suspect's confession was found to be false and he was released. The police then collected thousands of DNA samples extracted from blood volunteered by men in the area. The assailant, Colin Pitchfork, asked a friend to provide a DNA sample for him. However, the friend was overheard telling acquaintances of Pitchfork's request. Once police obtained a blood sample from Pitchfork, his DNA profile was found to be a perfect match with the DNA profiles extracted from the semen found on both victims. Pitchfork pleaded guilty and received a life sentence in 1988 for his heinous crimes. This was the first case in which DNA evidence was used both to exonerate an innocent man and to convict the perpetrator.

A vast amount of genetic variation exists in human populations and, except for identical twins, all people are genetically different. Forensic typing is based upon this genetic variation. Analysis of genetic variation requires that such differences are traceable. We refer to such traceable features as markers. Millions of people share the same blood groups, so this is not very helpful for identification purposes. However, the discovery of DNA markers made it possible to effectively distinguish between people. From a genetic perspective, what differs between people is the sequence of the four nucleotides on the DNA molecule. Interestingly, only five percent of our DNA is made up of

genes that code for all the proteins our body needs to grow and function. Very little variation between people exists in these genes or coding regions. However, some regions in the other 95 percent of our DNA that do not code for any proteins are highly variable and may be used to distinguish people from one another. As the purpose of many of these non-coding chromosomal regions is unknown, they are loosely referred to as 'junk DNA'.

The DNA markers used for forensic purposes are found in a number of different chromosomal locations or loci within the non-coding regions of the DNA molecule. The chromosomal locations chosen for forensic DNA analysis are termed short tandem repeats (STRs) as, at each locus, a pattern of two or more nucleotides is repeated in what has been termed a 'genetic stutter'. At each locus, there are two forms (alleles) of the repeated sequence; one is maternally inherited, the other paternally. The number of repeats of these DNA sequences varies considerably amongst individuals and thus allows scientists to differentiate between people. A person's DNA profile is simply a list of the number of repeats of a given sequence at every paired chromosomal location under analysis. It is important to note that the number of variations at any one STR locus is limited and thus numerous loci are considered in any forensic analysis. The more STR regions that are tested simultaneously, the lower the probability of any two individuals sharing a profile. To ensure that no two people tested have the same DNA profile, between nine and 13 locations on different chromosomes are tested simultaneously.

The process of obtaining a DNA profile begins with forensic experts taking a biological sample such as blood, semen, skin, saliva or hair from a person, crime scene or body. The genetic material, or DNA, is isolated from the sample and quantified. This is then referred to as the DNA sample.

Selected fragments containing the forensic DNA markers or STRs are then replicated using a process known as PCR (polymerase chain reaction), which can be described as a form of molecular photocopying. After being placed in a special gel, the fragments are separated according to their length using an electric current, a process called electrophoresis. A laser then lights up fluorescent tags on the fragments so that the fragment length of each STR marker can be measured. The fragment length is determined by the number of repeats of a given sequence at every chromosomal location under analysis. The resulting patterns, which resemble supermarket barcodes,

are photographed and examined and converted into a digital profile. The fragment length of each STR marker is recorded as a series of numbers. This sequence of numbers is termed the DNA profile. The resultant DNA profile is, in other words, the electronic representation of the physical DNA sample.

The process of obtaining a profile is illustrated in Figure 1. The illustration refers to one STR marker (specific region on a chromosome) on chromosome 11. This STR consists of repeat units of the nucleotide sequence ATCT. On one DNA strand, there are seven repeats of the nucleotide sequence and on the other strand, there are five repeats. The DNA profile is recorded and, if required, stored on a database as a sequence of numbers, in this case seven and five. In South Africa, ten marker regions are simultaneously analysed and thus a sequence of up to 20 numbers will make up the DNA profile.

Uses of DNA profiling

DNA profiles may be used to:

- identify potential suspects whose DNA matches evidence found at crime scenes;
- exclude a suspect quickly by demonstrating that a person was not involved in a particular crime scene or crime;
- identify patterns of criminal behaviour through matching DNA profiles found at several crime scenes – this may help solve past, current and even future crimes (in other words, not only will DNA profiling increase the likelihood of identifying unknown perpetrators, but it will also increase the possibility of linking perpetrators to multiple crime scenes);
- promote plea bargains when suspects are confronted with real evidence in the form of a DNA match (for example, in Britain, 85 percent of suspects plead guilty when presented with a match of their DNA to the crime);
- exonerate persons wrongly accused of crimes;
- identify victims of disasters;
- establish paternity and other family relationships;
- identify endangered and protected species when wildlife officials wish to prosecute poachers;
- detect and identify micro-organisms polluting the air, soil or water.

Figure 1: Process of obtaining a DNA profile

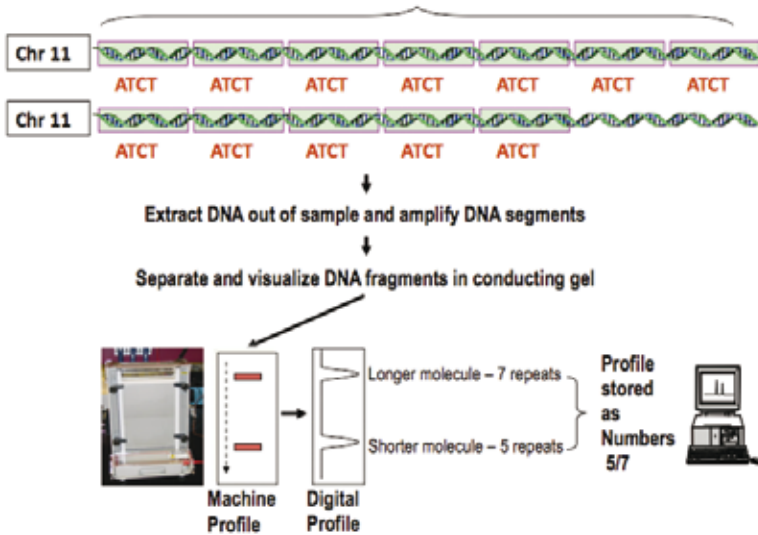


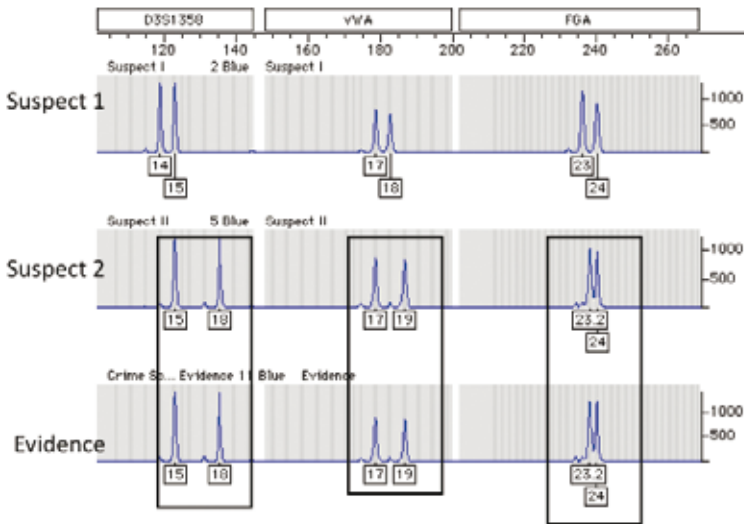
Figure by Prof. Annabel Fossey and Dr Carolyn Hancock

Crime detection

Forensic science provides the link between a crime scene and a suspect. Since 1901, fingerprinting has been used to track offenders. However, currently, the forensic tool of choice is DNA profiling, as evidence may be collected in many forms such as hair, blood, saliva, semen and perspiration. While blood, saliva and semen are still the main sources of DNA for forensic testing, trace amounts of DNA, for example from epithelial cells from the surface of the skin, can now be acquired from touched objects. Scientists can compare the saliva on the rim of a glass, or the skin cells and hair shed on a cap, with a suspect's blood or saliva sample. Similarly, DNA collected from the perspiration on a hat or scarf discarded by a rapist can be compared with DNA in the saliva swabbed from the bite mark on a different rape victim.

Figure 2 illustrates the comparison of three DNA profiles. Two are from suspects and one is the DNA profile obtained from evidence collected at a crime scene. It is clear that the evidence taken from the crime scene matches the DNA profile of Suspect 2, because the sequence of numbers (the DNA profile) is identical to the evidence.

Figure 2: Simplified example of the comparison between a crime scene sample and two suspects?



Sample	Chromosomal locations (STRs) under analysis		
	D3	vWA	FGA
Suspect 1	14; 15	17; 18	23; 24
Suspect 2	15; 18	17; 19	23.2; 24
Evidence	15; 18	17; 19	23.2; 24

In criminal investigations, the sequence of numbers from a DNA profile found at a crime scene may be compared to that of a known suspect. Alternatively, where there is no suspect for a particular crime, DNA samples collected at a crime scene may be compared with DNA profiles stored on a national DNA database. This resource contains DNA profiles of people suspected and convicted of offences, as well as DNA profiles obtained from evidence left at crime scenes. A match or 'hit' between the crime scene evidence and a database profile may identify a new suspect. This can help to identify or rule out a potential suspect at an early stage, thereby saving valuable police and other crime detection resources, leaving them free for other investigations.

For this reason, a national DNA database is considered to be one of the most powerful tools in crime prevention and detection used in the world today.

The time, effort and expense required to develop DNA databases are justified by the fact that:

- Criminals tend to reoffend. For example, 90 percent of rapists and 50 percent of armed robbers have a previous conviction.⁴
- The severity of crimes committed by repeat-offenders often increases over time, with criminals committing their first offence between the ages of 16 and 19 years.⁵
- A small number of criminals are often responsible for numerous crimes. DNA databases can assist in linking these crimes to one another.

Because individual DNA is as personal as a fingerprint, DNA collected from a crime scene can either link a suspect to evidence or eliminate him or her as a suspect. When evidence from one crime scene is compared with that from others, the crimes can be linked nationwide. As DNA retains its integrity, evidence from crimes committed years previously may yield sufficient DNA for analysis and point to a suspect.

In a UK study conducted by Alaster Smith in 2004,⁶ the following detection rates were recorded when DNA was recovered from a crime scene:

Crime	Detection rate: no DNA	Detection rate: with DNA
Overall	23%	43%
Domestic burglary	15%	46%
Theft from a vehicle	7%	61%
Criminal damage	13%	52%

In another study,⁷ 500 crime scenes in five different communities were studied. Both DNA processing and traditional methods of investigation were used to detect the crimes. The study found that in the cases where DNA evidence had been processed, more than twice as many suspects were identified. In addition, in cases where DNA evidence had been used, the number accepted for prosecution was double that compared with those using traditional methods of investigation.

Case study: DNA as a crime-solving tool

That DNA profiling can be used as a tool in crime detection – and as a means of convicting the guilty and exonerating innocent people – was highlighted in South Africa after the brutal attack, in October 2001, on a nine-month-old baby, now known as Baby Tshepang. Her 16-year-old mother had left Baby Tshepang in her home, where she was attacked and viciously raped in the early hours of the morning. The baby was found by her grandmother and rushed to hospital.

This horrifying attack provoked outrage in the local community and six local men were swiftly arrested for the presumed gang rape of the baby. Media stories on the case prejudged the guilt of these men, and the word 'alleged' was often missing from reports. The six were assumed to have gang-raped the baby and spent three months in jail, where they all reported being beaten by the police. All six men lost their jobs. In January 2002, DNA tests revealed that there was a sole rapist and that none of the accused had a DNA profile that matched that of the assailant. The six falsely accused men were immediately released and exonerated of the crime. In March 2002, police arrested David Potse, a former boyfriend of Baby Tshepang's mother. Potse was shown to be an exact DNA match with the rapist and was sentenced to life imprisonment. This case could not have been solved without DNA evidence and was particularly revolutionary in South Africa, where the conviction rate for child rape is a mere three percent.⁸

Because individual DNA is as personal as a fingerprint, DNA collected from a crime scene can either link a suspect to evidence or eliminate him or her as a suspect.

In the USA an organisation called The Innocence Project has been set up to assist in the exoneration of wrongfully convicted people through the use of DNA testing. The organisation was founded in 1992 and to date has been instrumental in successfully exonerating 235 people, 17 of whom served time on death row. The average sentence served by those exonerated by DNA before their release is 12 years in prison. In all

these cases, DNA testing provided irrefutable proof of wrongful convictions, as well as invaluable links to the actual perpetrators of the crimes.

In addition to the conventional markers used by forensic scientists to produce a DNA profile, there are also specific DNA markers located on the Y-chromosome that are found only in men. DNA profiling of sequences on the Y-chromosome is particularly useful in the case of rape victims, where it may be difficult to distinguish the female victim and her male assailant from a vaginal swab. In such cases, STRs on the Y-chromosome will allow the male fraction to be identified. Furthermore, if multiple perpetrators are suspected of the rape of one woman, STRs located on the Y-chromosome will

permit the number of perpetrators to be estimated.

Due to the fact that most violent crimes and almost all cases of sexual assault involve male perpetrators, forensic laboratories are increasingly using markers located on the Y-chromosome.

Case study: Overturning wrongful convictions

Wrongful convictions result primarily from the misidentification of a perpetrator by eyewitnesses, as was the case with Robert Clark in 1982. Clark was convicted of rape, kidnapping and armed robbery following the highjacking, brutal assault and rape of Patricia Tucker. Ms Tucker incorrectly identified Clark as her assailant and he was subsequently given a life sentence. Clark maintained his innocence throughout the 24 years of his wrongful incarceration. The Innocence Project took on his case in 2003. In 2005 a vaginal slide collected after the rape was sent for DNA testing and revealed that Clark could not have contributed the sperm found on the slide as it did not match his DNA. On the basis of the DNA evidence, Clark was released from prison and his conviction overturned. The Innocence Project then asked that the DNA profile obtained from the vaginal slide be compared with DNA profiles held on state convicted offender databases. The sample matched that of Tony Arnold, a prisoner already serving time for sodomy and cruelty to children. Arnold's DNA profile was also shown to match two other rape cases.

Paternity testing

DNA profiling is used to establish biological relationships between people. Paternity testing is the most common form of kinship testing, with hundreds of thousands of tests being conducted worldwide every year. A child receives half of its DNA from each of its parents, forming a genetic 'profile' of a unique set of characteristics. A comparison of the DNA profiles of mother, father and child determines the child's parentage.

The method used in kinship or parentage testing is identical to that described for crime scene investigation. However, the interpretation of the results is more complicated than matching evidence to a suspect. This is because, in the case of kinship analysis, there will not be an exact match between the DNA profiles obtained from relatives.

Due to the fact that most violent crimes and almost all cases of sexual assault involve male perpetrators, forensic laboratories are increasingly using markers located on the Y-chromosome.

Case study: Y-chromosome markers

Y-chromosome markers were used to free Clarence Elkins, incorrectly incarcerated for rape and murder, and to convict the true perpetrator. Elkins was wrongfully accused of the rape and murder of his 68-year-old mother-in-law and the rape of his six-year-old niece. The conviction was based entirely on his niece's testimony at the trial.

There was no physical proof of his guilt. Biological evidence, including hairs, was collected from the crime scene and the victims at the time. DNA testing conducted before the trial on pubic hairs found on the bodies of each of the victims excluded Elkins as a possible suspect. Nevertheless, Elkins was convicted of rape, murder and attempted murder and received a life sentence.

During his incarceration, Elkins managed to provide his own funding for Y-STR testing on evidence from the crime. This evidence excluded Elkins as a suspect, as his profile differed from the one identified using male skin cells from both the grandmother's vaginal swab and the young girl's underwear. Elkins moved for a new trial, but the motion was denied. In the meantime, Elkins' wife, working with a private investigator, came to believe that a convicted rapist, Earl Mann, was guilty of the crime. When Mann was transferred to the same cellblock, Elkins retrieved a cigarette butt Mann had dropped in the prison yard and mailed it to his wife. His wife had the butt tested and the results matched the vaginal swab and the stain found on the girl's underwear. Elkins was subsequently found innocent and released – after serving six and a half years in prison for a crime he had not committed. Faced with the DNA evidence, Mann pleaded guilty to aggravated murder, attempted murder, aggravated burglary and rape.

We all contain two copies (alleles) of each marker, one inherited from our mother and the other from our father. In the case of paternity testing, one would expect one allele of each pair at every chromosomal location (marker) to be found in both the DNA profiles of the father and the child.

Figure 3 overleaf illustrates this principle. The child has obtained two alleles for the marker under consideration; one is nine repeat units in length and the other 20. Each of these must have originated from one of her parents. If the 'dad' under investigation did not have either of these alleles, he would be excluded as a possible parent. If eight markers are considered and half of the child's alleles correspond with eight of the mother's and the other eight with the man's, the chances are 99.88 percent or greater that the man is the father.

Figure 3: The fundamental principle behind determining parentage

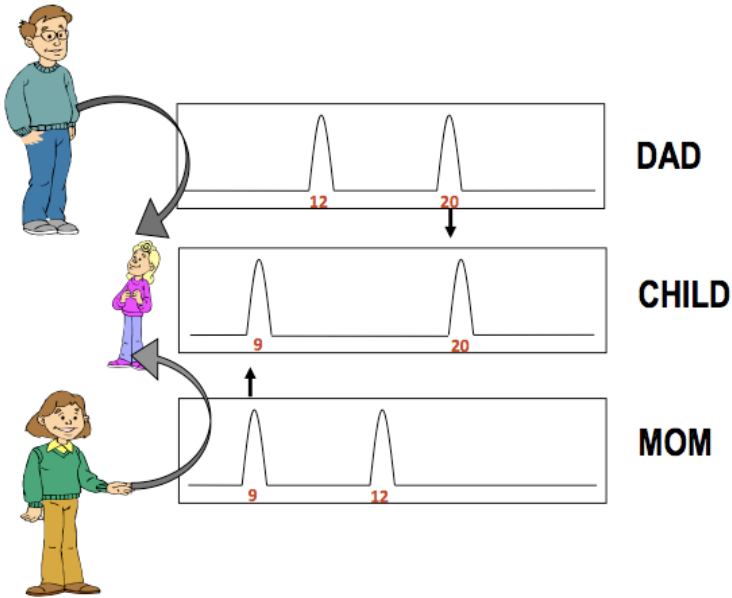


Figure by Prof. Annabel Fossey and Dr Carolyn Hancock

Case study: Determining parentage – Happy Sindane

The case of Happy Sindane is a South African example of using DNA to determine parentage. The teenager, who is fair-skinned and has blonde hair, claimed to have been abducted from a white family by a black woman. When the intrigue surrounding his origins and genealogy broke in the media in 2003, there were rumours of kidnapping and maltreatment. DNA parentage tests, however, confirmed that he had in fact been born to a black African mother. The courts found that Happy Sindane had been born Abbey Mzayiya in Thembisa Hospital on 25 June 1984 to Rina Mzayiya (a black South African). Mzayiya's employer, Henry Nick, a white German living in South Africa at the time, is thought to be his father. However, Mzayiya left Happy in 1990 with Betty Sindane and Thomas Banda, who raised him in Tweefontein, Mpumalanga, for two years. After this Betty's father, Koos, cared for him.

Case study: Determining parentage – The 'taxi twins'

A further South African example of the use of DNA profiling to determine parentage has been called by the media 'the case of the taxi twins'. A mother allegedly took her week-old twin babies to a taxi operator in Johannesburg to demand maintenance. The taxi driver refused and, after an argument, slammed the door of the taxi and drove away. The driver later took the babies to the Langlaagte police station and, because he was afraid of being arrested, he lied about the babies' paternity. He told the police that a passenger had left the twins behind in his taxi. Thereafter, seven different women came forward claiming to be the mother of the babies. DNA profiling was used to establish the real parentage of the twins. DNA tests confirmed that the mother was a 31-year-old woman who lived in an informal settlement near Langlaagte and that the taxi driver was in fact their biological father.

Identification of human remains

DNA profiling may be used to identify badly decomposed bodies. This is usually done using variable DNA sequences that exist in the genetic material of organelles found in large numbers in every cell in a person's body. These organelles, called mitochondria, contain their own non-chromosomal DNA, and are passed directly from a mother to her children. Consequently all people who share a female relative will have the same mitochondrial DNA. Comparisons between mitochondrial DNA profiles obtained from human remains and living female relatives can thus provide clues to the identity of badly charred or decomposed bodies.

Mitochondria have two attributes that are utilised in forensic investigations:

- Mitochondria occur in large numbers in the cell. This is useful in the identification of decomposed bodies when the amount of cellular material available for analysis is very small. The analysis of mitochondrial DNA is commonly used in the analysis of hair shafts, bones and teeth.
- Mitochondria are inherited solely through the female line. This is a useful trait for the identification of human remains and missing persons. As the missing person's biological mother, siblings and maternal relatives will all have the same mitochondrial DNA sequence, biological samples taken from them can provide references for the identification of the missing person. It must however, be borne in mind that mitochondrial DNA varies less between individuals than DNA found in

the nucleus, which means that more individuals chosen at random from a population will have the same mitochondrial DNA profile. The mitochondria may thus not provide conclusive proof of the identity of a body.

Case study: Identifying human remains

DNA profiles obtained from mitochondrial DNA from exhumed bodies were used to correctly identify the remains of anti-apartheid activists by the missing persons task team set up by the National Prosecuting Authority as a result of the hearings of the Truth and Reconciliation Commission. These included identifying four anti-apartheid activists who were abducted in 1987. These men were tortured, their bodies dismembered by explosives and their remains buried in a common grave in a cemetery north of Pretoria. In addition, this technology was used to identify ten young activists, from a township near Pretoria, who were lured into a trap by members of the then Northern Transvaal security police. The activists were injected with a substance to render them unconscious. They were then placed in a minibus and the vehicle was set alight with petrol and a limpet mine, with the intention of making it look as if the activists had been killed in a motor vehicle accident. The severely burnt remains were found in a series of graves at the Ga-Rankuwa state mortuary. Mitochondrial sequences obtained from bone specimens of the decomposed bodies were found to match sequences from living maternal relatives of the deceased.⁹

The maternal inheritance of mitochondrial DNA is particularly useful when there are no direct relatives to use as a reference sample.

Case study: Mitochondrial DNA

An example is the identification of the skeletal remains of the Russian royal family. In 1991, nine sets of skeletal remains were excavated from a mass grave near Yekaterinburg in Russia. The remains were believed to include Tsar Nicholas II, the Tsarina Alexandra and three of their daughters. The Romanov family had been killed by a firing squad and their bodies dumped in a pit north of the city. Mitochondrial DNA sequences of the presumed Tsarina and her daughters matched that of Prince Philip of Britain, a known maternal relative, verifying the identity of the family group. In addition, mitochondrial DNA sequences from bone of the presumed Tsar matched two of his living maternal relatives. Furthermore, analysis of mitochondrial DNA from skeletal remains of the Tsar's brother, Georgij Romanov, matched that of the putative Tsar, proving conclusively that the remains found included those of Tsar Nicholas II and his family.¹⁰

Case study: Identifying victims

DNA technology was also used to assist in the identification of 1 594 of the 2 749 victims of the World Trade Center bombings in New York on 9 September 2001.¹¹ The technology used was groundbreaking, as many of the remains were intermingled and water and fire at the site had badly degraded many specimens. As a result, different types of DNA profiling techniques were used, including STR and mitochondrial DNA analysis. In total, 19 915 samples were analysed. In 86 percent of cases, DNA was the sole method of identification. DNA profiles obtained from the victims' remains were compared with profiles obtained from their personal effects, such as toothbrushes, hairbrushes and razors. In addition, comparisons were made with DNA profiles of close relatives.

3. Ethical issues associated with DNA profiling

Like a fingerprint, a DNA profile acts as a unique identifier, and can be used to identify or exclude a suspect of a crime. Some concerns, however, have been raised by human rights groups around issues such as the taking of DNA profiles from persons arrested but not subsequently convicted of an offence and the retention of their DNA profiles for criminal intelligence purposes on a DNA database. This section seeks to address these concerns through the careful consideration of the context in which DNA profiles are stored on a national DNA database and the reasons why a retention framework needs to be in place.

The debate relates to whether the retention of the DNA profile of a supposedly innocent person constitutes an invasion of their privacy. Many people mistakenly believe that all of their genetic information is contained in a DNA profile obtained for criminal intelligence purposes. It is for this reason that the retention of a DNA profile on the database must be measured against the type of information that could compromise that individual.

With regard to obtaining and interpreting a DNA profile, the following facts are crucial: (i) A DNA profile is stored on the DNA database as a sequence

of numbers, which simply act as a unique identifier. (ii) The DNA Profile is obtained from a set of only nine to 13 markers located in the 'junk' or 'non-coded DNA', ensuring that no genetic disposition or other distinguishing feature may be read from the profile. One cannot tell from looking at a fingerprint whether the owner of that print has a pre-disposition to cancer, and this principle applies equally to a DNA profile processed for entering into a DNA database. This is because the STR loci used in crime detection have no biological function, therefore this kind of information does not become available to the profiler. Furthermore, many genes and numerous environmental factors determine most diseases and behavioral tendencies, and it is very unlikely that a mere correlation between a non-coding region of DNA (STR) and a physical or behavioural characteristic will allow anyone to accurately predict these conditions.

Many people mistakenly believe that all of their genetic information is contained in a DNA profile obtained for criminal intelligence purposes.

The purpose for which a DNA profile may be used is furthermore limited to the detection of crime, the investigation of crime or the conduct of a prosecution and, most importantly, to entering the DNA profile into the DNA database. The presence of a DNA profile on a national DNA database does not constitute or signify a criminal record, nor does it impact on the individual in any way, particularly if that individual has no intention of ever committing a crime. Furthermore, the misuse of either samples or data taken for entering into the national DNA database is punishable by law.

Retention of DNA profiles on a criminal intelligence database

It is imperative that in South Africa all DNA profiles remain on the database indefinitely, as their use for future criminal intelligence is important. There is no inference of guilt attributed to the DNA profile by virtue of its retention on the database and there is no means of identifying the profile's owner by the sequence of numbers displayed. The DNA profile will remain dormant on the database unless its owner commits a crime. The only time it will be recalled is when there is a match between a person and a crime.

It is important to retain profiles on a DNA database because many criminals reoffend. Research carried out by the Jill Dando Institute (JDI)¹² shows that only 15 years after their first offence is the probability of a criminal reoffending the same as that of the general population. Furthermore, the JDI research shows that 52 percent of criminals commit another offence within the first six years of the initial arrest. The studies were based on data collected from people who have been arrested and convicted in the UK.

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Case study: Retaining DNA profiles

The following case study illustrates an instance where the retention of a DNA profile led to the later arrest and conviction of a dangerous criminal. A suspect, Mr L, was arrested in the UK in 2002 for possession of a weapon. His DNA was taken on arrest and loaded onto the national DNA database. The proceedings against the suspect were dropped but the profile was retained. In 2004, a rape was committed in northern England, and the DNA of the unknown suspect was taken from the victim. The unknown DNA profile was loaded onto the national DNA database and a speculative search was conducted against all known profiles. A match was found between the unknown suspect's DNA and a known sample, that of Mr L. His DNA profile had been retained on the national DNA database despite non-conviction on the previous charge. Mr L was convicted in 2005 and jailed for five years and his name was entered into the sex offenders' register for life.

The above study not only illustrates the importance of retaining DNA profiles on a DNA database, but also shows that the initial offence for which a suspect is arrested does not necessarily correlate with any subsequent offences that he or she may go on to commit. A good example of such a 'criminal career path' is the notorious 'Yorkshire Ripper', who was caught through his theft of a number plate from a scrapyards. A criminal career often begins with relatively minor offences that may lead to more serious, violent offences in the future. Some criminals may tend to be criminally versatile in that they commit a wide variety of offences throughout their criminal careers. Not entering a DNA profile into a database in respect of minor offences, or offences that do

not result in a conviction, negates the effect of a DNA database as a criminal intelligence tool and reduces its potential as a crime deterrent.

As previously discussed, a DNA profile obtained for entry onto the NDDSA is a sequence of between nine to 13 numbers or 'markers' derived from the non-coded region of the DNA sample, thus ensuring that no genetic disposition or other distinguishing feature may be read from the profile. It is accordingly the retention of an individual's DNA sample once a profile has been obtained that is raised as a concern by some people, as it is theoretically possible to sequence a person's genetic make-up from a DNA sample, thereby obtaining information of a personal nature. It is for this reason that proposed new legislation in South Africa will not allow for the retention of DNA samples taken from suspects once a full DNA profile has been obtained and loaded onto the DNA database. In contrast, a crime scene sample will form part of the evidence used to build a case and aid in an investigation, and, as such, it will be retained indefinitely in the same way as any other form of 'real' evidence, such as a bullet casing or a weapon found at a crime scene.

It has been found that some ethnic groups become over-represented on a DNA database, as police officials may focus more attention on and arrest more people from certain ethnic groups. This could be problematic if there is any stigma attached to having a profile on the DNA database. It is argued by some that a universal database that included the entire population would alleviate

In countries such as South Africa, where crime levels are unacceptably high, both the state and human rights organisations have recognised that a person's right to privacy has to be weighed up against the public's right to safety.

any concerns regarding discrimination and maximise the police force's ability to detect crime. However, the associated costs would be substantial and the increase in crime detection would be negligible. Consequently in South Africa and globally, DNA databases are comprised primarily of convicted offenders and those suspected of committing crimes.

A further cause for concern is the retention of children's profiles on a database.

It is important to ensure that children are protected from any perceived stigma attached to having their DNA profiles on a database and to ensure that every opportunity is provided to rehabilitate child offenders back into society.

It must be reiterated that the presence of a DNA profile on a national DNA database does not constitute or signify a criminal record. Nor does it impact on the individual in any way, particularly if that individual has no intention of ever committing a crime. There should thus be no stigma attached to people whose DNA profiles are stored on the DNA database.

It is understandable that individuals have an expectation of privacy regarding their DNA information. However, in countries such as South Africa, where crime levels are unacceptably high, both the state and human rights organisations have recognised that a person's right to privacy has to be weighed up against the public's right to safety. The protection of the public from criminals is an obligation of the state. The authority to obtain a DNA profile from someone arrested on suspicion of a crime and to retain their profile on a DNA database is thus warranted as it furthers the state's ability to detect and prevent criminal activity.

Methods used to obtain a DNA profile from a suspect

DNA profiles are obtained from a suspect using non-invasive techniques such as a buccal swab or finger prick. If we consider that in South Africa, we already allow the police to demand a breath or blood sample when a person is suspected of impaired driving, then taking a swab from a person's mouth is no more intrusive.

In *S v Orrie*¹³ the accused argued that being subjected to a blood test for the purpose of compiling a DNA profile would infringe on his fundamental rights to dignity, freedom and security, the right to bodily integrity, the right to privacy, and the right to be presumed innocent and not to have to assist the prosecution in proving its case as set out in the Constitution.¹⁴

The Court held as follows in this regard that:

There can be little doubt that the involuntary taking of a blood sample for the purposes of DNA profiling is both an invasion of the subject's right to privacy and an infringement, albeit slight, of the right to bodily security and integrity. To the extent, however, that the involuntary taking of a blood sample from an accused for the purposes of compiling a DNA profile for use in criminal proceedings infringes

his or her right to privacy, dignity and bodily integrity, I am of the view that the limitation clause of the Constitution (s 36 of Act 108 of 1996) permits the limitation of these rights, through the medium of s 37 of the Criminal Procedure Act. I consider that, taking into account the factors set out in s 36(1)(a)-(e), such a limitation is necessary and justifiable in an open and democratic society based on human dignity, equality and freedom. Put differently, the taking of blood samples for DNA testing, for the purposes of a criminal investigation, is a reasonable and necessary step to ensure that justice is done and is reasonable and necessary in balancing the interests of justice against those of individual dignity.

Reliability of DNA profiling technology

In general, the science and technology of DNA profiling is robust and reliable. However, there are always risks associated with the use of biological information. These include the deliberate or accidental contamination of samples; the misinterpretation of samples containing the profiles of more than one person (mixtures); the misinterpretation of partial profiles and the misuse or misinterpretation of statistics used to describe the probability of a match. It is thus imperative that regulatory bodies rigorously monitor quality assurance to ensure reliability and accuracy of collection, analysis and interpretation of DNA evidence. Also, there should be extensive education of the general public, police, emergency service personnel and the legal profession on the nature of biological evidence and its correct interpretation.

Case study: The importance of accurate information

Miscarriages of justice that have arisen from prosecutors refuting DNA evidence may be seen in the famous O.J. Simpson case, as well as locally following the brutal murders of Jan Smit and his wife in Pretoria in 2001. In the O.J. Simpson case, Simpson, a football star and actor, was found not guilty of the murders of his ex-wife Nicole Brown Simpson and her friend Ronald Goldman in 1994, even though his blood was found at the murder scene and the victim's blood was found inside his car and home. The DNA test results carried out on the bloodstains found at the crime scene showed that there was only a one out of 57 billion chance that another person would have the same DNA profile as the one that matched the crime stains and O.J. Simpson. Fifty-seven-billion is approximately ten times the current population of the entire world and yet, at a time when forensic DNA profiling was in its infancy, Simpson's lawyers managed to convince the jury that there still remained 'reasonable doubt' that Simpson was the murderer, as the blood sample evidence might have been mishandled by laboratory scientists and technicians.¹⁵

In the South African case of the murders of the Smit couple, an 'expert witness' contracted by the defence team used a delaying technique of demanding reams of documents regarding the proficiency and management of the local Forensic Science Laboratories (FSL) and their equipment. The defence team managed to pummel witnesses from the FSL with so many questions that even the judge declared himself confused. DNA evidence showed that blood of the accused was found at the murder scene and that the blood of the murdered Mr Smit was found on one of the accused's chefs' knives. Statistical calculations suggested that only one in 604 billion people would have the same DNA profile as the accused and its perfectly matching profile, found in the form of a bloodstain at the crime scene. Following the doubt cast on the FSL by the defence, the crime scene and reference samples were sent to the Forensic Science Services (FSS) in Britain to verify the results. The FSS confirmed every significant result and finding of the FSL. These results and the proficiency of the world's leading forensic DNA analysts were then also brought into question by the defence team, and the judge, refusing to postpone the case any further after awaiting endless reams of documents, declared the case closed. With the accused released, many people believe that the defence team and their 'expert witness' erroneously let a murderer walk free.¹⁶

In conclusion, it can be stated that with regard to the use of STRs and privacy concerns, the information contained in the DNA profile itself (a list of numbers) is largely meaningless, except as a unique identifier. Furthermore, legislation in countries that use national DNA databases clearly states that bio-information stored on DNA databases may only be used for preventing, detecting and prosecuting crime or for identifying a deceased person or body part. Notwithstanding the fact that there will always be fears regarding the accuracy of profiling and the chances of error resulting in a wrongful conviction, this is counteracted by the far more common occurrence of the use of DNA evidence to exonerate people who have been convicted of crimes they did not commit, as well as by the overwhelming number of suspects who plead guilty when confronted with DNA evidence.

4. Criminal intelligence DNA databases

Current trends and international best practices

The advent of DNA typing and its use for identity testing have revolutionised law enforcement investigations throughout the world by allowing forensic laboratories to match suspects with minuscule amounts of biological evidence from crime scenes. Equally important is the use of DNA to exclude suspects who were not involved in a crime, or to identify human remains in an accident. The past two decades have seen numerous advances in DNA testing procedures. Technologies for measuring DNA variations have also advanced rapidly in the past decade. The time needed to determine a sample's DNA profile has dropped from up to eight weeks to one or two days. With more recent advancements, the time needed to process samples may decrease to as little as a few hours.

The evolution of DNA markers and technologies embraced by the forensic community and the acceptance and use of DNA typing information has occurred simultaneously. The courtroom battles over statistical issues that were common in the late 1980s and early 1990s have subsided as DNA

evidence has become more widely accepted. In the past ten years, national DNA databases have emerged as powerful tools for criminal intelligence and investigations, much like the fingerprint databases that have been used routinely for decades. National DNA databases are springing up in countries all over the world as their value to law enforcement is recognised. In South Africa, we are still in the process of elevating the status of our national DNA database to an international level of acceptance, which, if achieved, will ensure that DNA evidence plays a key role in crime detection and prevention. This can be attained through a massive drive to educate the people involved in detecting and convicting criminals of the value and accuracy of DNA evidence in resolving unsolved crimes. The people who need to be trained include first-at-crime-scene police officers, crime scene investigators, emergency services as well as court officials and the general public.

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It is not possible, within the scope of this paper, to explore the policies and legislative frameworks governing the application and operation of each and every country's national DNA database. The following examples touch on the implementation, development and success of selected countries' respective DNA expansion programmes, followed by a comparative overview of the current situation in South Africa.

The United Kingdom

The world's first national DNA database was established in the United Kingdom in April 1995, following a Royal Commission into the criminal justice system. The British national DNA database (NDNAD), developed as a means of contributing to the efficiency of crime detection, has become the international benchmark of DNA databases. Data held on this database has become increasingly central to the practice of criminal investigation in the United Kingdom. DNA profiles are stored anonymously with minimum detail, such as the sample number. A separate register is maintained with the personal records associated with each profile in the database. The two segments

comprising the database are the Criminal Justice Database (containing DNA taken from persons suspected, reported, charged, convicted, or cautioned for any recordable offence) and the Crime Scene Database (containing DNA gathered from crime scenes). In contrast to South Africa, there has been a compulsory system in force of DNA sampling of criminals in Britain and a national database of those samples for nearly ten years. Every person convicted of all except relatively minor offences in Britain must provide a DNA sample. This process of collection has become instrumental in building up a working database, it being widely acknowledged that serial offenders often start with petty crimes before committing serious violent crimes.

The British government started the DNA expansion programme in April 2000 and it currently contains in the region of five million profiles. The DNA expansion programme was successful in achieving the following:

- DNA database legislation was enacted.
- Funding was ring-fenced for forensic staff, vehicles and equipment.
- DNA awareness training was implemented – police force, justice system and general public.
- There was an increase in ‘volume crime’ scenes visited, resulting in an increase of DNA retrieved from crime scenes. By definition, ‘volume crime’ includes the majority of offences that are committed in England and Wales, and as such has a significant impact on many victims. These include theft, burglary, theft from motor vehicles, garages and sheds being broken into, criminal damage and other crimes.
- There was an increase in the number of crime scene profiles loaded onto the NDNAD.
- The use of the NDNAD in crime detection rates was regularly monitored.
- The IT infrastructure of the NDNAD was improved.
- Match reports were delivered electronically.

The NDNAD now provides the police with around 3 000 matches each month. Benefits realised as a result of the DNA expansion programme in the Britain were many:¹⁷

- DNA detections quadrupled over a five-year period.

- There was a 75 percent increase in number of suspect-to-crime-scene matches.
- It enhanced the capacity to detect and solve serious crimes.
- The collection of all types of forensic material was supported.
- Links to other crimes – multiple matches – increased.
- Innocent people were exonerated.
- Cold cases were solved.
- Scene-to-scene matches identifying patterns of criminal behaviour became possible.
- DNA processing times and costs were reduced.
- There was a reduction in crime levels.

The DNA expansion programme began with the enactment of the following legislation:

- Rooted hair and mouth swabs were reclassified from ‘intimate’ to ‘non-intimate’ samples.
- Non-intimate samples were allowed to be taken without consent from any individual arrested for a recordable offence and detained in a police station, irrespective of whether the sample was relevant to the crime being investigated or whether the person arrested was convicted or acquitted of the alleged offence.
- Samples and profiles were only allowed to be used for purposes related to preventing and detecting crime, investigating an offence, conducting a prosecution or identifying a deceased person or a body part (for example, as a result of death from natural causes or mass disasters).
- Samples taken from volunteers were able to be loaded onto the database with written consent, which consent was deemed to be irrevocable.
- All DNA profiles loaded onto the DNA database were retained indefinitely.

Case study: Balancing human rights

The widely published case of *S & Marper*¹⁸ recently reached the European Court of Human Rights (ECHR), which ruled that the 'blanket' policy in England and Wales of retaining DNA profiles in respect of all people who were arrested but not convicted, was a breach of Article 8 of the European Convention of Human Rights. The ECHR however, also indicated that the retention of DNA profiles does pursue 'the legitimate purpose of the detection and, therefore, the prevention of crime'. The Home Office, which is compelled to comply with these findings, responded to this judgment by proposing that the 'blanket' policy be replaced with a retention framework which, in the words of the European Court's judgment, will 'discriminate between different kinds of cases and for the application of strictly defined storage periods for data'. In so doing, it is believed that a retention framework, as described, will have the effect of achieving compliance with the judgment handed down by the ECHR whilst maximising public protection.¹⁹

The significance of the Marper ruling and the Home Office response is that other administrations will draw precedence from this judgment and its effect, particularly South Africa, which is in the early stages of formulating its own legislation to ensure that similar future challenges are not directed against it. The key is to make certain that the maximum number of detections is achieved through the application of the DNA database as a criminal intelligence tool whilst ensuring compliance with the principles espoused in the ECHR ruling. If this can be achieved in South Africa through the careful drafting of legislation regarding retention policies in respect of the profiles of non-convicted suspects, then the expansion and success of the NDDSA will be secured.

Canada

The DNA Identification Act of 1998 provided for the establishment of a DNA database. It amended the Criminal Code of Canada to provide a mechanism for a judge to order persons convicted of designated offences to provide blood, buccal or hair samples, from which DNA profiles could be derived. The Act includes strict guidelines on genetic privacy and stipulates that samples collected from convicted offenders can only be used for law enforcement purposes. The Canadian DNA database is, therefore, restricted in its application to convicted offenders and is limited to those convicted of designated offences, as defined in the Criminal Code. Canada's DNA database manages two principal indexes, namely: the Convicted Offender Index and the Crime Scene Index, containing DNA profiles obtained from crime scenes.²⁰ The Act provides that information in the Convicted Offender Index

is kept indefinitely, but allows for the removal of the person's profile if the person's conviction is set aside or if the person is subsequently acquitted of the offence. It additionally provides for the retrospective collection of profiles.

The Supreme Court of Canada in *R v Rodgers* (2006) sanctioned the legality of the Canadian DNA database and the retrospective collection of profiles. The Court held that:

DNA sampling is no more part of the arsenal of sanctions to which an accused may be liable in respect of a particular offence than the taking of a photograph and fingerprints. The fact that the DNA order may have a deterrent effect on the offender does not make it punishment.

The United States of America

In the late 1980s, groundwork was put into place by the United States Federal government to begin a system of national, state and local DNA databases for the storage and exchange of DNA profiles. The system was named the Combined DNA Index System (CODIS) and was made available to the law enforcement agencies for their use in solving crimes. CODIS forms the core of America's national DNA database. It was developed by the FBI specifically to enable public forensic DNA laboratories to create searchable DNA databases of authorised DNA profiles. CODIS also has the ability to test and compare DNA database profiles obtained from convicted offenders and can link DNA evidence from different crime scenes that can identify possible serial criminals.

CODIS was initially thought to benefit the investigation of sexual assault cases, but has been proven to have a much wider and more useful application in the investigation and prosecution of crimes. Due to the centralisation of the CODIS system throughout the USA, it now provides a central database of DNA profiles from all user laboratories. Laboratories can conduct weekly searches of the DNA profiles in this database, known as the National DNA Index System (NDIS). Any resultant matches generate an automatic response to the laboratory that originally processed the DNA profile.²¹

CODIS uses two indexes to generate investigative leads in crimes for which biological evidence is recovered from a crime scene. The Convicted Offender Index contains DNA profiles of individuals convicted of certain crimes,

ranging from misdemeanors to sexual assault and murder. The Forensic Index contains DNA profiles obtained from crime scene evidence, such as semen, saliva, or blood. CODIS uses computer software to automatically search across these indexes for a potential match. Because of the crime-solving abilities of CODIS, states began to pass laws in the late 1980s and early 1990s requiring convicted offenders of specific crimes to give DNA samples. Today, all fifty states and the federal government have passed laws regulating DNA profiling for use as a criminal intelligence tool.

South Africa: The current situation

Currently, DNA analysis to support the South African Police Service (SAPS) is provided by two state Forensic Science Laboratories (FSL, also known as biology units), one of which is in Pretoria and the other in Cape Town. The Pretoria biology unit is the largest and houses the NDDSA. Research in the field of forensic biology is conducted at the University of the Western Cape and a number of private laboratories are involved in paternity testing.

It is regrettable that despite the profound success of DNA analysis and its revolutionary effect on the resolution of crime throughout the world, it has, until recently, been an alien concept to many key figures in authority in South Africa, as well as throughout the justice system.

In 2006, the world's first fully automated robotic system for forensic DNA profiling became operational at the Pretoria biology unit. The equipment was financed by the European Union at a cost of 8.35 million Euros. The system is controlled by 27 personal computers and incorporates eight robots. This system is potentially capable of analysing 800 reference samples a day.²²

The Pretoria and Western Cape biology units also make use of a manual system for DNA profiling. However, it is regrettable that despite the profound success of DNA analysis and its revolutionary effect on the resolution of crime throughout the world, it has, until recently, been an alien concept to many key figures in authority in South Africa, as well as throughout the justice system. As a result, the FSL's potential use of the NDDSA as a criminal intelligence tool has been limited by factors such as a deficiency of

Key recommendations	
<p>Establish a DNA database against which to run crime scene evidence.</p>	<p>Expanded DNA databases can only be effective in practice if:</p> <ol style="list-style-type: none"> 1) More qualified staff is appointed to attend to crime scenes and to work as forensic analysts; 2) Training of staff is provided by a tertiary institution in South Africa; 3) More equipment is provided, as required, to enable the finalisation of more print and sample analyses per month; 4) A DNA and fingerprint collection education drive (online training or mobile training bus) and national awareness campaign with all role-players, as to the importance of preserving a crime scene, collecting DNA samples and prints, etc. Role-players will include: crime scene experts, detectives, police generally, prosecutors, magistrates, guards from private security companies, etc.
Projected outcome	
<p>Increase in identifications made possible from DNA collected at crime scenes.</p>	<p>More samples and prints will be collected to run timeously against the expanded databases to enable more hits to be made.</p>
Achieved through	
<p>Legislative amendments or new legislative proposals:</p> <ol style="list-style-type: none"> 1) Establishing DNA database – management, etc.; 2) Providing for collection of DNA profiles from all accused and convicted persons AND providing for the retention of such profiles, even if accused found not guilty or the prosecution discontinued. BUT, making it clear that profiles so retained may only be used for the purpose of the prevention or detection of crime, the investigation of an offence or the conduct of a prosecution. 	<ol style="list-style-type: none"> 1) Allocating resources for the appointment of staff, buying equipment and investing in training. 2) Developing a new management system: focus will no longer only be on DNA case-by-case analysis on request of a prosecutor (the current working method) adopted in order to prioritise cases for court. Although this line of work will continue, a second work stream will have to be developed in which the focus is on building up a national DNA database and allowing ongoing inter-case searches; 3) Training trainers to conduct education drives throughout the country and with all role players, allocating resources towards this initiative and developing the necessary training materials.

DNA profiling equipment, a lack of appropriate funding, outdated legislation, embargoes on processing crime stains and DNA profiles without a known suspect, inadequate laboratory capacity, outdated information systems, overwhelming caseloads, and a shortage of training.

South Africa does not have any specific legislation that regulates the existing DNA database. Currently, section 37 of the Criminal Procedure Act (51 of 1977) is the only statutory provision that deals with the ascertainment of bodily features of an accused. Section 37 makes no mention of the collection of DNA evidence since it was drafted long before the advent of DNA profiling. It is nevertheless regarded as the legislative source for the current gathering of DNA evidence. In other words, the taking of DNA profiles and the storing of those profiles on the NDDSA is currently being done in a legal vacuum.

The DNA Bill ensures that the creation of a DNA database will function effectively, not only as a tool for gathering incriminating evidence but also for gathering evidence to eliminate suspects and so safeguard against wrongful convictions or other miscarriages of justice.

In order to address this shortfall, the Office of the Criminal Justice System Review, tasked with identifying challenges which have an impact on the efficiency and effectiveness of our justice system, identified as a priority the need to strengthen the forensic gathering capacity of the SAPS. To this end, the Criminal Law (Forensic Procedures) Amendment Bill B2-2009 (hereafter referred to as the 'DNA Bill') was drafted and adopted by the Cabinet in December 2008. The DNA Bill, currently still under review by Parliament, seeks to address gaps in our current

legislation dealing with the collection, storage and use of DNA evidence and to provide for the expansion and administration of a national DNA database, which will be called the National DNA Database of South Africa (NDDSA).

The DNA Bill, in essence, addresses the following issues:

- It deals with all aspects of biometric evidence, especially the use of DNA profiles for criminal intelligence purposes.
- It seeks to expand and upgrade the existing DNA database within the SAPS (for example, by allowing police to take a DNA sample from

all accused and to keep the DNA profile on the database regardless of a subsequent conviction).

- It establishes and provides for the management and administration of the NDDSA to include all suspect and crime scene profiles.

The DNA Bill aims to achieve these objectives while providing for strict safeguards and penalties to ensure that forensic materials are collected, stored and used only for purposes related to the detection of crime, the investigation of an offence or prosecution.

Legislating policies and procedures to institute the expansion of the NDDSA is a matter of some urgency, both because of the potential value of DNA as a law enforcement tool and because of the civil liberties issues that these practices raise. The DNA Bill adequately addresses these issues and has been carefully drafted to ensure that the NDDSA is used to its full potential in combating and preventing crime in South Africa while ensuring that it has minimal impact on the civil rights of citizens. In addition, the DNA Bill ensures that the creation of a DNA database will function effectively, not only as a tool for gathering incriminating evidence but also for gathering evidence to eliminate suspects and so safeguard against wrongful convictions or other miscarriages of justice.

It is not known exactly when the legislation will be passed, but most likely it will be operational from the beginning of 2010. In the absence of such a legislative framework, the very high numbers of perpetrators who are not detected, combined with the high number of cases withdrawn before reaching court and leading to very low conviction rates, will continue to undermine all efforts in the fight against crime.

The table on page 32, prepared by the Department of Justice and Constitutional Development,²³ responsible for drafting the DNA Bill, illustrates the key legislative changes required to operate and manage the NDDSA.

For the effective management of the NDDSA, the new DNA Bill proposes the creation of five different sections, or 'indexes':

- Crime Scene Index, containing DNA profiles collected from crime scenes;
- Reference Index, containing DNA profiles taken from persons suspected, reported, charged or cautioned for any recordable offence;

- Convicted Offender Index, containing convicted offenders' DNA profiles;
- Elimination Index, containing DNA profiles of people working in the collection and analysis of forensic samples;
- Volunteer Index, containing DNA profiles of victims, as well as persons requesting their profiles to be kept on the database (parents may volunteer to record their children's DNA in case they ever go missing).

The Crime Scene Index, Reference Index and Convicted Offender Index are the most crucial for criminal intelligence, as they play an important role in the resolution of crime. The Crime Scene Index will ensure that a crime scene sample is taken from the scene of a crime (hair, blood or semen, for example),

Given the recidivistic nature of most crimes in South Africa, the likelihood exists that the perpetrator of the crime being investigated may have already been convicted of a similar crime and may have his or her DNA profile on the NDDSA.

where the perpetrator is unknown. Given the recidivistic nature of most crimes in South Africa, the likelihood exists that the perpetrator of the crime being investigated may have already been convicted of a similar crime and may have his or her DNA profile on the NDDSA, which can then be searched for against the other profiles already stored on the NDDSA. Moreover, this type of speculative searching permits the cross-comparison of DNA profiles developed from biological evidence found at crime scenes, which are known as crime scene-to-crime-

scene matches. Even if a perpetrator is not identified through the NDDSA, crimes may be linked to each other in this way, thereby aiding an investigation and potentially leading to the identification of a suspect.

Of note is the inclusion of the Convicted Offender Index retroactively. The DNA Bill makes specific provision for the retrospective taking of convicted offender samples. The rationale behind obtaining DNA profiles from all convicted criminals is that research has shown that:

- It acts as a deterrent and addresses the question of accountability, both of which pose huge issues in South Africa in respect of criminals repeatedly committing crimes.

- It can be used to link an offender with previous crime scenes where DNA profiles have been obtained.

The length of retention of DNA profiles has been raised as an issue in the DNA Bill in South Africa, particularly in respect of profiles retained where no conviction has taken place. It is submitted that the Marper ruling, and the way in which the British Home Office applies it, will have a bearing on what the Parliamentary Portfolio Committee will recommend to be enacted in the DNA Bill. Research conducted in Britain has found that the risk of an arrestee being re-arrested will fall as the number of years from the arrest increases.²⁴ This is called a declining 'hazard-rate'. The relevance of this risk rate, they argue, is that if the risk of re-arrest remains higher for someone who has been arrested but not convicted compared to that for the general population, then there is justification for retaining that profile on the DNA Database.

The retention framework on page 37 has been proposed by the UK Home Office, in respect of DNA profiles.

The current rate of recidivism in South Africa is one of the highest in the world. Research has shown that there is a high possibility of convicted offenders repeating crimes either after release or during parole. By retaining the DNA profile, any subsequent crime scene evidence may be linked immediately to that person, whose full details will be on the DNA database.

A DNA database is only really successful at identifying possible suspects if its reference index contains enough DNA profiles of known individuals to run a speculative search against DNA profiles derived from crime scene samples. Currently, South Africa has a hit rate of only 0.02 percent because our crime scene DNA profiles far outnumber reference DNA profiles.

The new DNA Bill will permit the police to build up the NDDSA by entering known or suspect DNA profiles into the Reference and Convicted Indexes and unidentified DNA profiles (crime scene profiles) into the Crime Scene Index. To find a match, forensic analysts compare the DNA profile obtained from crime scene evidence to the profile from a known individual (suspect or victim). It goes without saying that the more 'known DNA profiles' that exist on the Reference and Convicted Offender Indexes, the greater the chance of there being a match when an unknown or crime scene profile is entered and run against these databases.

Typically, there are three possible laboratory outcomes when a DNA profile is entered onto the NDDSA:

1. If the DNA profile from a crime scene and a known DNA profile are identical, forensic analysts interpret this finding as a 'match' or 'hit'.
2. If the two profiles are not consistent, the finding is interpreted as a 'non-match' or 'exclusion'.
3. If there is insufficient data to support a conclusion, the finding is regarded as 'inconclusive'.

Type Of DNA profile	Retention period – UK
Adults convicted of a recordable offence	Indefinite
Adults arrested for but not convicted of a recordable offence which is not a serious violent or sexual or terrorism-related offence	Automatically deleted after 6 years (but subject to an automatic retention of a further 6 years if re-arrested during this 6 year period)
Adults arrested but not convicted of a serious violent or sexual offence or terrorism-related offence	Automatically deleted after 12 years
Volunteer samples (e.g. for elimination purposes)	Not stored on the database
Exceptional grounds for early deletion of profiles (per regulations setting out criteria for these grounds)	On application to the Chief Constable
Children under 10 years	Will not be retained on the database
Persons under 18 (but over 10) years who are convicted of a serious violent, sexual offence or terrorism-related crime	Indefinite
Persons under 18 (but over 10) years who are convicted on only one occasion of a lesser offence	Removed on turning 18 years
Persons under 18 years who are arrested but not convicted for a serious violent or sexual offence or terrorism-related offence	12 years
Under 18 years who are arrested but not convicted on only one occasion of a lesser offence	6 years or deleted on turning 18 years

Note: all samples obtained from suspects on arrest will be destroyed, regardless of conviction or acquittal; samples will only be retained for as long as needed to extract a suitable profile for entry onto the DNA database.

If we compare match results between South Africa and the United Kingdom (which has the largest DNA database per capita in the world), we see that the total number of profiles on the British DNA database, in particular the high number of known DNA profiles, generates a higher number of hits. Over a five-year period, Britain matched 17 285 crime scenes with DNA profiles on their DNA database. In other words, the crime scene profile of an unknown perpetrator was linked to another crime scene where the same profile had been found; that is, the same person committed both crimes.

In South Africa, over a ten-year period, less than a hundred samples found at crime scenes matched the same profile found at another crime scene. Given the level of crime in this country and the high rate of recidivism, it is clear that the NDDSA is not working nearly as effectively as the British DNA database. This is directly related to the fact that there are not enough profiles to search against on the NDDSA. If, however, we increase the number of profiles on the NDDSA, we will directly increase the chance of finding a match and linking it to a suspect. At the very least, criminal intelligence could be derived from the Crime Scene Index to be used to close in on the unknown suspect, his or her modus operandi, area of operation and possible linked profiles, which may then indicate a syndicate.

Of the total number of profiles (both known and unknown) on the British database, there is an immediate match rate of 52.2 percent, compared to South Africa's 0.02 percent. The increased hit rate in Britain can be traced back to the implementation of DNA legislation, coupled with a DNA expansion programme supported and funded by the British government. That programme resulted in an additional two million profiles being loaded onto the database over four years. If the same approach were adopted in South Africa, there is no doubt that the hit rate would increase considerably, and that an overall reduction in crime would ensue.

The table on page 39 illustrates how the huge increases in international databases have contributed valuable intelligence to hundreds of thousands of police investigations, not only in violent crimes but also in cases that are notoriously difficult to solve, such as burglary and vehicle theft.

Size and effectiveness of major national DNA databases²⁵

Database and date					
	UK Feb 2006	Europe Dec 2005	USA April 2006	Canada May 2006	New Zealand April 2005
Total profiles	3 693 494	987 671	3 275 710	123 603	63 678
Offender profiles	3 406 488	772 355	3 139 038	94 999	54 159
Crime scene profiles	287 006	215 316	136 672	28 604	9 419
Investigations aided	721 495	116 057	34 193	5 963	2 451

The effectiveness of DNA databases in identifying a suspect can be illustrated by the conviction of a man guilty of a series of attacks on elderly women in North Carolina in 1990. Over a period of a few months, three elderly women were brutally raped and murdered in isolated incidents. DNA analysis of biological evidence collected from vaginal swabs of the three rape victims enabled authorities to conclude that the same man had committed all the crimes. However, there was no suspect.

Given the level of crime in this country and the high rate of recidivism, it is clear that the NDDSA is not working nearly as effectively as the British DNA database.

More than ten years later, after the start of a DNA database in North Carolina, the DNA profile developed from the three sets of crime scene evidence was compared against thousands of convicted offender profiles already on the database. A hit was made with a person previously convicted of shooting into an occupied dwelling. When confronted with the DNA evidence, the suspect confessed to all three crimes and justice was finally served.²⁶

The expansion of the NDDSA is directly linked to the implementation of the new DNA Bill, which will allow for the inclusion of all types of profiles as well as speculative searching between the different indexes. The success of the NDDSA will also be achieved through its continued expansion. That

means profiles must be allowed to be added and retained on the database to ensure its growth. A policy that calls for an unconditional restricted time period to retain profiles will erode the NDDSA and decrease its effectiveness over time. The larger the NDDSA, the more powerful it is as a criminal intelligence tool.

5. South Africa: The DNA Project

The DNA Project is a non-profit, public benefit organisation that recognises the critical importance of DNA evidence in the resolution of crime. It is committed to advancing justice through the expanded use of DNA evidence in conjunction with a national DNA criminal intelligence database. The DNA Project hopes that its efforts will translate into the comprehensive use of DNA analysis for crime detection and prevention in South Africa.

In order to expand and develop the NDDSA, the DNA Project has recognised that the following key areas need to be addressed: legislation, education and the expansion of the Forensic Science Laboratories.

Legislation

The NDDSA has great potential to be used as a criminal intelligence crime-fighting tool. However, a major limitation on the ability to develop intelligence from the NDDSA is South Africa's current legislation, which prevents personal samples being taken from suspects, arrestees and convicted offenders for inclusion on the DNA database. At present, the balance of the number of profiles

on the NDDSA is heavily biased towards crime scene profiles, as opposed to suspect (person) profiles. Consequently there is a limited number of profiles with which to match crime scenes to suspects.

A major limitation on the ability to develop intelligence from the NDDSA is South Africa's current legislation, which prevents personal samples being taken from suspects, arrestees and convicted offenders for inclusion on the DNA database.

The DNA Project is therefore lobbying public support for legislative changes in the Criminal Procedures Act.

The DNA Project has contributed towards the drafting of the new DNA Bill, which has recently been accepted by the Cabinet and is currently under consideration by a Parliamentary Portfolio Committee. The DNA Bill is intended to expand the powers of the police to collect and store DNA samples and fingerprints, thereby expanding the NDDSA.

The advantages of this legislation, once promulgated, will include:

- helping the police detect more crimes and match suspects to crime scenes;
- increasing the likelihood of identifying unknown perpetrators and assisting in linking perpetrators to multiple crime scenes;
- using DNA evidence to prove the innocence of an accused person;
- using DNA evidence to identify missing persons or unidentified human remains.

Education

Postgraduate qualification

Currently in South Africa, there is no specific training course for forensic biologists. An objective of the DNA Project is therefore to develop a group of competent, professional personnel to perform forensic science examinations that will assist the courts of law to ensure crime resolution. To meet this objective, the DNA Project has been working together with the Criminal Justice System Review Task Team to develop a course aimed at training people with specific skills in forensic DNA analysis.

This qualification will formalise a learning pathway in the field of forensic biology, and will assist in setting the standard of competence required

for entrance into this professional field as well as provide a vehicle of transformation within the forensic biology sector. The qualification is targeted at the fourth year post-matric level (equivalent to Honours or a three-year Bachelor of Science). Qualified learners specialised in forensic DNA analysis will be equipped with the underpinning detailed knowledge of DNA typing and analysis to competently analyse and reconstruct a crime scene, analyse and interpret forensic findings, and provide forensic evidence in a court of law.

DNA awareness training

The DNA Project believes that in order for the NDDSA to be effective, the quality and quantity of DNA samples delivered to the FSL for analysis must be optimised. To this end, it believes that rigorous training needs to be implemented amongst key sectors of the SAPS and community, namely, amongst lower level police officers, emergency services and security services, as well as the general public. All of these sectors need to be able to assist in containing – as opposed to contaminating – a crime scene, thereby

Qualified learners specialised in forensic DNA analysis will be equipped with the underpinning detailed knowledge of DNA typing and analysis to competently analyse and reconstruct a crime scene, analyse and interpret forensic findings, and provide forensic evidence in a court of law.

enabling trained forensic personnel to collect and retain usable DNA evidence for profiling and subsequent prosecution.

Currently, the DNA Project publishes general crime scene awareness guidelines on its website (www.dnaproject.co.za) in an effort to disseminate this important information. However, it is necessary to address a wider audience through the implementation of specialised training courses, training material and the media. To this end, the DNA Project is investigating the development of a mobile training facility to assist with the training of lower-level police officers in the correct handling of crime scenes (where currently a large amount of crucial evidence is lost).

In addition, the DNA Project is sponsoring the development of a CD-ROM to be used for training purposes. The CD-ROM will contain basic information about DNA profiling, the NDDSA and current legislation. This information

will be of benefit to all officers and trainees, whatever their role or rank, as it will enable them to use the technology of DNA profiling to provide intelligence and corroborative evidence in crime investigations.

The interactive learning package will:

- provide a simple overview of DNA, the techniques of DNA profiling and the benefits of a national DNA database in crime investigation;
- identify the responsibilities of the first officer attending the crime scene in relation to potential DNA evidence;
- identify the potential sources, locations and limitations of DNA evidence;
- teach the importance of the correct handling and packaging of samples from crime scenes, suspects and complainants;
- provide information relating to the legislation regulating the use of DNA as an evidential tool.

The Forensic Science Laboratories' capacity

The purchase and supply of DNA profiling equipment to the FSLs (biology units) has been an ongoing function of the DNA Project in order to tangibly assist the units in South Africa, as well as create an awareness of the challenges they face. The donation of equipment has in addition been found to raise the morale of staff working at the units, as it illustrates that the public is supportive of their efforts and recognises the limitations under which they currently work.

The DNA Project contracted the services of the British Forensic Science Service (FSS), which is responsible for managing the world's largest national DNA database. The FSS and the British national DNA database are considered worldwide to be the benchmark for DNA forensic practice and the effective use of a DNA database for criminal intelligence purposes. The FSS conducted a diagnostic

It is has become critical that the South African government consider convening a body of strategically placed people to develop a DNA database expansion strategy that will oversee and coordinate the activities required to meet these objectives.

review of South Africa's FSLs and the NDDSA. This review provided information on issues such as scene-of-crime requirements, legislative impact, as well as technical laboratory processes and procedures currently used within the FSL. The outcome of the diagnostic review by the FSS was a comprehensive findings report with recommendations and proposed solutions which are meant to support the enhancement of DNA processing and the use of an effective national DNA database in South Africa.

In conjunction with the above key issues, it has become critical that the South African government consider convening a body of strategically placed people to develop a DNA database expansion strategy that will oversee and coordinate the activities required to meet these objectives. In addition, a large investment needs to be made by the South African government to ensure that these key objectives are met and to enable the significant benefits of a national DNA database to be achieved.

The DNA Project's objectives not only address the backlog of DNA samples currently awaiting analysis, but also seek ways in which to ensure that the size of the national DNA database is increased to maximise its potential as a criminal intelligence tool. The DNA Project has identified that this can be achieved by: specialist analyst training and continuing education; purchasing additional upgraded laboratory and computer equipment and supplies; scientifically validating and implementing new forensic technologies; modifying facilities and making use of contractor-provided services for assistance in implementing new capabilities and for outsourcing reference casework to streamline processes.

6. South Africa: Where to from here?

DNA evidence, when used to its full potential, has helped, and will continue to help, solve and prevent some of the most serious violent crimes taking place in South Africa today. Before this can happen, the current systems need to be reviewed, and some of them replaced, to ensure that we are able to fully utilise the benefits of DNA profiling as a crime-fighting tool. In conclusion, it is submitted that the following basic advances need to be made in South Africa, and quickly, to achieve this objective:

- Policy-makers and law-makers must promulgate legislation that will provide a basic legal structure that regulates and uses DNA profiling for criminal intelligence to ensure the continued use of DNA testing in the criminal justice system.
- Solutions must be found to address the backlogs of unanalysed DNA samples currently waiting processing in state forensic laboratories, either through outsourcing samples for processing or increasing the number of laboratories to help cope with the current backlog.
- Equipment in existing forensic laboratories needs to be continually

updated and increased to help decrease delays in getting results and ensure that more profiles are processed for entry onto the NDDSA.

- Forensic scientists working in forensic laboratories must be required to have up-to-date, specialised training to be able to perform their jobs at the highest level to make DNA technology solve crimes.
- First-on-crime-scene police investigators, as well as key personnel involved in crime scenes including the private security and emergency services sector, must be trained in how to identify, collect and preserve DNA evidence at crime scenes, so that critical evidence can be collected and fewer cases will be at risk of being jeopardised due to the mishandling of evidence.
- Officers of the courts must be educated in how DNA evidence technology works to corroborate a case against a suspect or exonerate a suspect quickly, thereby decreasing delays in court.

With all the above requirements adhered to, DNA profiling in a criminal context will help reduce the scourge of crime prevalent in South Africa today in a smart, advanced and constructive manner.

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