Solving crime with DNA

What is the real story around DNA and crime scenes? **Vanessa Lynch** and **Carolyn Hancock** look at the facts.

CSI has undoubtedly become one of television's most popular series. But, while many of the scenarios and characters depicted in *CSI* are far from believable, continuous references to the cutting-edge DNA technology used by the *CSI* crime labs in solving their cases are not too far from the truth. Moreover, the use of DNA profiling for criminal intelligence in this popular TV series has increased public awareness to the point where people cannot conceive of a case being investigated without DNA – regardless of whether the case calls for it or not! But how much of these TV programmes is actually fact and how much is fiction? Let's look at the facts and establish to what extent forensic DNA technology is used in South Africa and to what effect ...

DNA in real life

A young girl is brutally attacked and viciously raped in the small town of Louisvale in the Northern Cape.

Her injuries are so substantial that gang rape is assumed. This horrifying attack provokes outrage in the local community and six men are swiftly arrested and subsequently spend the next three months in jail – for their own safety, as the community have threatened them with their lives for committing this monstrous attack. All six men lose their jobs. On examining the case the public prosecutor calls for DNA analysis to be used to assist in the investigation. First, samples are taken from the crime scene, which in this instance is the young girl herself. A doctor collects DNA samples from her clothing and body, which are sent to the forensic science laboratory's DNA unit for analysis. In the meantime, DNA reference samples are also taken from the six suspects and sent to the same laboratory for analysis to determine whether the DNA profiles of these six men match those analysed from the samples taken from the victim.

The DNA results reveal an unexpected turn in the investigation as they show that only one rapist is responsible for this terrible attack and that none of the six accused men have a DNA profile that matches that of the real assailant. Based on these results, the six falsely accused men are immediately released and cleared of the crime.

Another suspect, a former boyfriend of the young girl's mother, is subsequently arrested and a DNA reference sample is taken from him and sent to the DNA laboratory for analysis. The DNA results show an exact DNA match with the rapist. He ▷▷

Sexual assault evidence packs awaiting analysis. Image: DNA Project

The Forensic Science DNA laboratory. Image: DNA Project

Table 1: Where to look for DNA

Evidence	Possible location of DNA evidence	Source of DNA
Knobkerrie, cricket bat or similar large blunt weapon	Handle end	Sweat, skin, blood tissue, hair
Hat, bandana or balaclava/mask	Inside item	Sweat, hair, dandruff
Sunglasses or reading glasses	Nose or ear pieces, lenses	Sweat, skin
Facial tissue, cotton wool swab, ear bud, wash cloth	Surface area	Mucus, blood, sweat, semen, ear wax
Clothing, including underwear word during AND after attack	Surface area	Blood, sweat, semen
Toothpick or dental floss	Tips	Saliva, semen, skin cells
Used cigarette	Cigarette butt	Saliva
Stamp or envelope	Licked area	Saliva
Tape, cable tie or ligature	Inside/outside surface	Skin, sweat, saliva, hair
Bottle, can or glass	Sides, mouthpiece	Saliva, sweat
Used condom	Inside/outside surface	Blood, semen, vaginal or rectal cells
Blanket, pillow, sheet	Surface area	Blood, sweat, hair, semen, urine, saliva
Bullet	Outside surface	Blood, tissue
Bite mark, area licked	Person's skin or clothing	Blood, saliva
Fingernail, partial fingernail	Scrapings	Blood, sweat, tissue

Scrapings from under fingernails can provide DNA samples. Image: DNA Project

A hijacking crime scene showing how the forensic pathologist dresses to prevent contamination (staged). Image: DNA Project

A forensic science laboratory in Pretoria in action. Image: DNA Project

DNA analysis relies on careful and accurate laboratory technique. Image: DNA Project

is sentenced to life imprisonment. in Pretori

This is not a scene from *CSI*, but an account of an true case, which occurred in South Africa. What is particularly significant in this case is that DNA not only proved the innocence of six people but also led to the conviction of the man who was the rapist. DNA can therefore be used not only to link suspects to a crime but to exclude innocent people from an investigation. Let us look closely at the steps taken by the police, the forensic analysts and the criminal justice system, which led to the exoneration of the six innocent men and successful prosecution of the real perpetrator.

The chain of evidence

The chain of events leading up to the conviction of the perpetrator by means of the revolutionary technology known as 'DNA profiling' begins at the crime scene itself. A crime scene is usually the physical area or location where a crime has been committed, which contains clues, or records, of what happened at the scene. It can also include the body of a victim, as in the case of sexual assault. Clues that perpetrators leave behind at a crime scene are what can be used to link them to that crime. These clues are called evidence. While evidence can include testimony from eye-witness reports, digital footage or a fingerprint, it can also be found in biological material, which contains DNA.

Forensic crime scene investigators (CSI personnel) are specially trained to look for biological samples which may contain DNA at the crime scene so that they can be used as evidence to link the person who committed the crime to the crime scene. As Edmond Locard, the father of forensic science, clearly stated more than 100 years ago, 'Wherever he steps, whatever he touches, whatever he leaves, even unconsciously, will serve as a silent witness against him. Not only his fingerprints or footprints, but his hair, the fibers from his clothes, the glass he breaks, the tool mark he leaves, the paint he scratches, the blood or semen he deposits or collects. All of these and more bear mute witness against him. This is evidence that does not forget.' This quote is often summarised in the famous phrase 'every contact leaves a trace' – the CSI's simply need to find the evidence and send any biological samples to the DNA forensic laboratory for further analysis.

Why is DNA evidence considered to be so valuable in investigations?

DNA is found in every cell (except red blood cells) in our bodies – it can therefore be found in biological samples left at a crime scene or on a victim's body, e.g. blood, semen, skin cells, tissue, organs, muscle, brain cells, bone, teeth, hair, saliva, mucus, perspiration and even fingernails. While blood, saliva and semen are the main sources of DNA for forensic testing, trace amounts of DNA, for example from epithelial cells, are now able to be acquired from touched objects, such as the handle of a weapon, the steering wheel of a stolen car or the inside of a glove. This is one of the reasons that DNA is such a useful form of evidence – it is almost impossible for criminals NOT to leave some of their cells behind at a crime scene! In addition, it remains unchanged throughout a person's life, and because every person has a unique DNA profile (except an identical twin), it does not matter whether a person is arrested years after they have committed the crime: if their DNA profile matches the DNA profile found on a crime scene years before their arrest, it indicates that they were present at the crime scene at the time the crime was committed.

What happens when the biological sample arrives at the forensic science laboratory?

Once the biological samples have been received at the forensic science laboratory, 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 regions under analysis, called short tandem repeats (STRs) are then replicated, using a process called 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 ▹▹

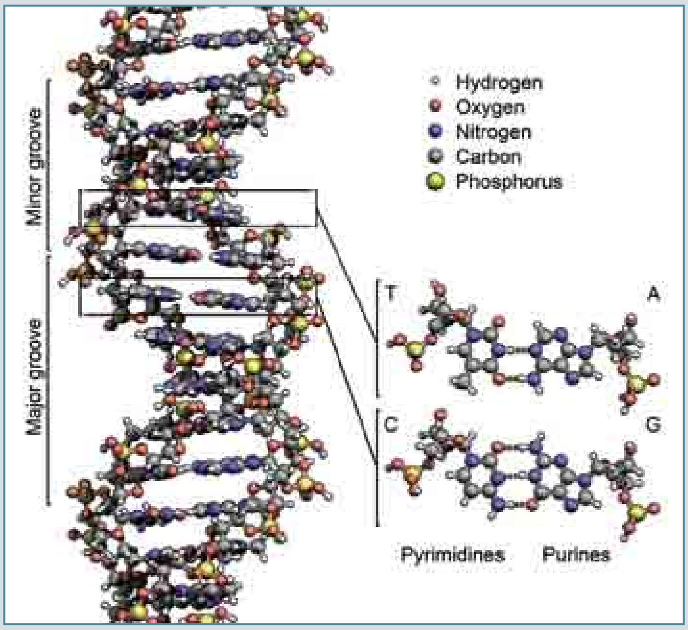
What is DNA?

DNA, or deoxyribonucleic acid, is a chemical found in almost all of the 60 trillion cells that make up our bodies. DNA is the 'instruction manual' that tells each of our cells how, where and when to function. For example, some cells will produce enzymes to digest food while others will determine what you look like – your height, skin, hair and eye colour.

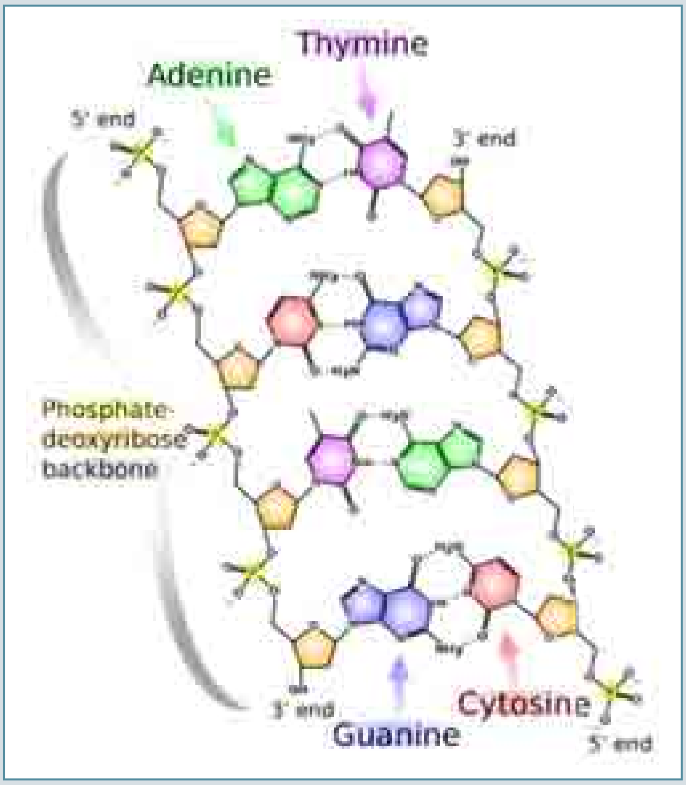
DNA consists of two long chains of subunits, twisted around each other to form a double helix. All DNA is made up of four components, called nucleotides. The nucleotides, or bases, are guanine (G), adenine (A), thymine (T) and cytosine (C). In a similar fashion to the way in which the 26 letters of the alphabet can be ordered to create a message, the instruction that the sequence of nucleotide bases in DNA delivers depends on their order. For example, 'mlaina' means nothing whereas 'animal' tells us we are considering a biological creature. Similarly a DNA sequence of C-T-T-G-A-T may be meaningless whereas C-G-T-C-T-A may be an instruction to manufacture a certain protein in your white blood cells. The instructions encoded in any specific combination of DNA bases (e.g. GATCCAT) directs all our biochemical processes by instructing the cell which amino acids to put together to form proteins. As our bodies are made up of and regulated by different proteins, our DNA determines all our characteristics and makes each of us unique.

DNA is contained within chromosomes, which are located in the nucleus of our cells. All people have 46 chromosomes arranged in pairs – one of each chromosomal pair coming from each of our parents. We have 22 pairs of chromosomes (called autosomal chromosomes) as well as two sex chromosomes. Males have one X chromosome, and a Y chromosome (46, XY), while females have two X chromosomes (46, XX). More than 8 trillion possible combinations arise from any two parents which is why none of us (except identical twins) are alike.

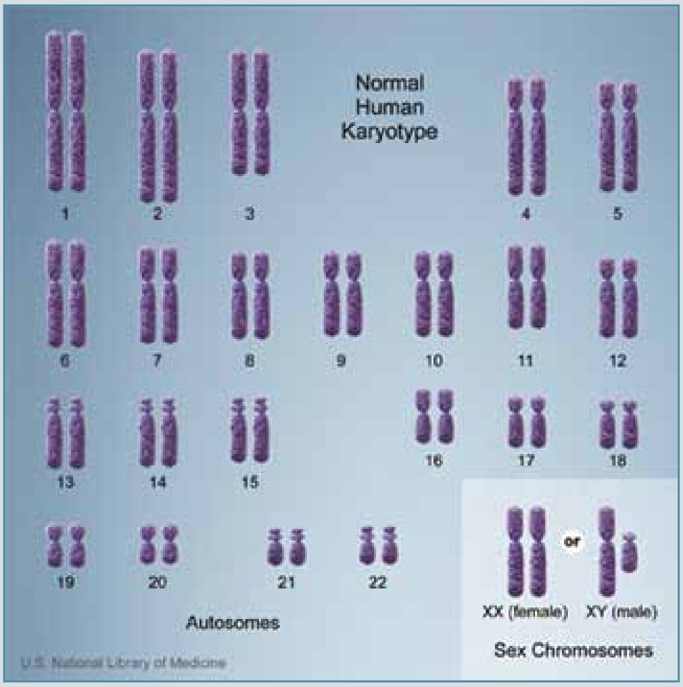
Just by observing people's appearance you will notice that none of us look the same (except identical twins) and that is because our DNA is different. What differs between people is the sequence of the four nucleotides on the DNA molecule. Interestingly, only 5% of our DNA is made up of areas called genes, which code for all the proteins that our bodies need for growth and to function. Very little variation between people exists in these genes or coding regions. However, some regions in



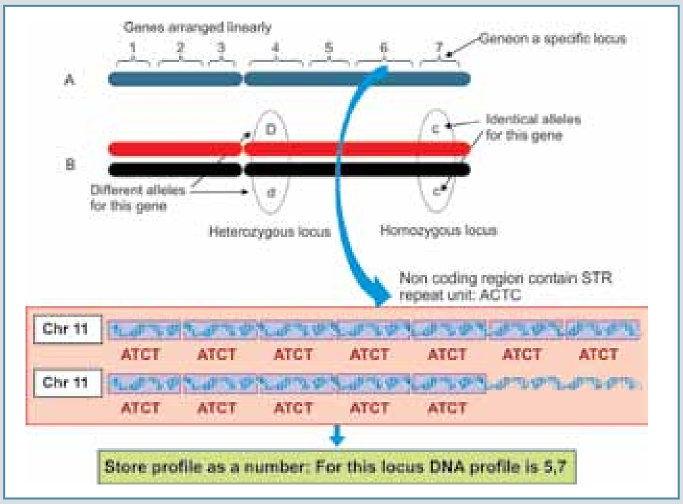
The structure of the DNA double helix. The atoms in the structure are colour coded by element and the detailed structure of two base pairs is shown in the bottom right. Image: Wikimedia Commons



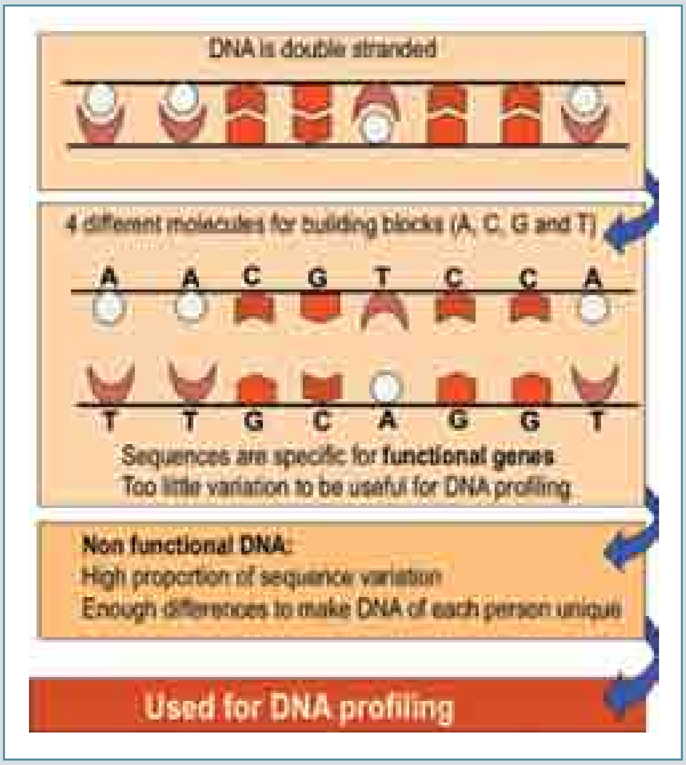
The chemical structure of DNA. Hydrogen bonds are shown as dotted lines. Image: Wikimedia Commons



A set of normal human chromosomes. Image: US National Library of Medicine



The way in which STRs are used in forensic DNA analysis. Image: The DNA Project



How DNA is used for a person's DNA profile. Image: The DNA project

the other 95% of the DNA, that do not code for any proteins, are highly variable and may be used to tell the difference between people. As the purpose of many of these 'non-coding' chromosomal regions is unknown they are loosely referred to as 'junk DNA'.

The stretches of our DNA that are used for forensic purposes are found in a number of different places (loci) within the non-coding regions of the DNA molecule. The chromosomal locations chosen for forensic DNA analysis are called short tandem repeats (STRs) because, at each locus, a pattern of two or more nucleotides is repeated in what has been termed a 'genetic stutter'.

An example would be the two nucleotides, A and C, repeated a number of times: e.g. ACACACACACAC which would be abbreviated to (AC)6 as the sequence is repeated six times. In any person there will be two forms (alleles) of the repeated sequence at every location under analysis; one is maternally inherited, one paternally. This means that you may inherit five repeats of the sequence from your father and ten from your mother. We would then say your genetic make-up at the place in your DNA where the AC sequence is repeated is 6,10. The number of repeats of these DNA sequences varies considerably among individuals and 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 chromosomal location (locus) under analysis. Forensic scientists analyse a number of loci simultaneously to make sure that no two people will have the same DNA profile. Currently in South Africa, ten loci are analysed to provide a forensic DNA profile. The greater the number of STR regions that are tested simultaneously, the lower the chance (probability) of any two individuals sharing a profile. By analysing ten loci there is less than one in a billion chance that two people will share a DNA profile. This is a very accurate science!

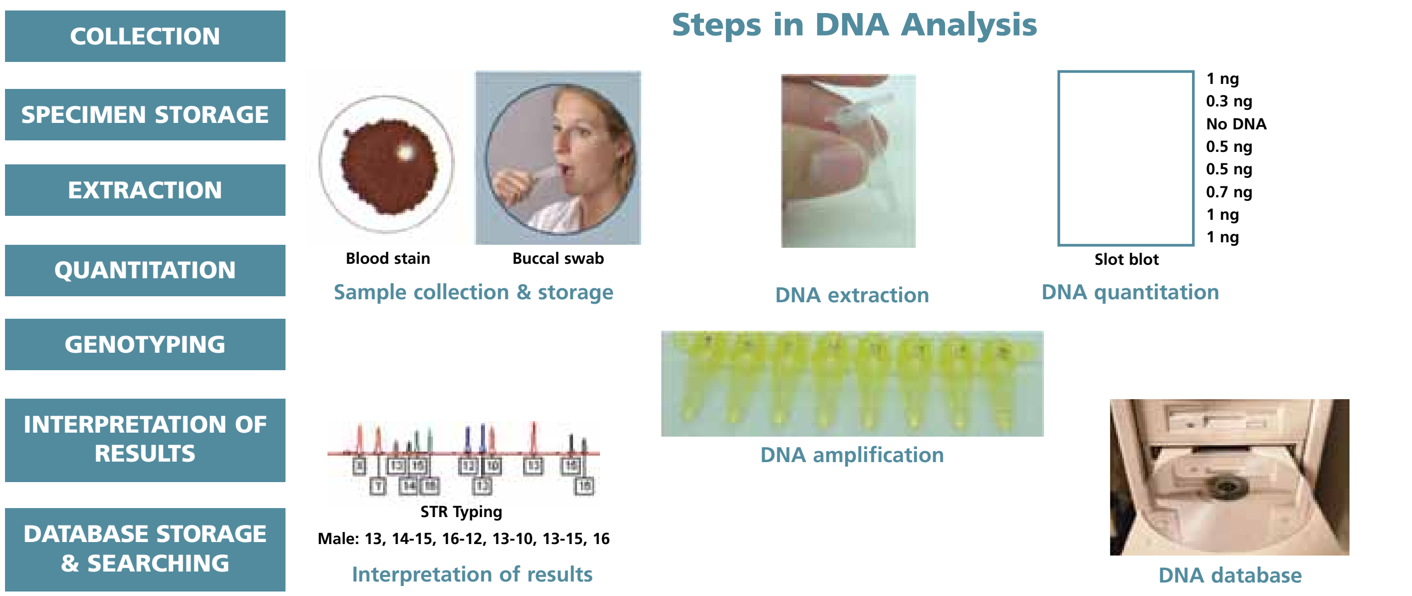
It is very important to remember that because forensic scientists analyse non-coded regions of our DNA, or 'junk DNA', a DNA profile does not provide any information regarding people's physical characteristics, apart from gender, and is used as a unique identifier only. Therefore the information gained from a DNA profile reveals no more about a person's private information than a conventional forensic fingerprint.

location under analysis. The resulting patterns 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 called the 'DNA profile'. The resultant DNA profile is a series of letters and numbers that are representative of the physical DNA sample.

How can we use DNA to link a suspect to a crime scene?

Once DNA profiles have been obtained from the evidential samples collected at the crime scene they will be compared to the DNA profiles obtained from known suspects as well as DNA profiles obtained from other crime scene evidence. Profiles that are obtained from known people are called 'reference profiles' and they are usually obtained from suspects, victims or other people that may have been at the scene such as crime scene investigators.

A typical DNA case would involve comparing the DNA profiles obtained from two types of samples: the unknown, or crime scene sample, such as semen from a rape, and a known or reference sample, such as a buccal or cheek swab from the suspect. If the resultant crime scene profile and the reference profile from the suspect are identical then this is called a 'match' or 'inclusion'. A pair of profiles is reported to 'match' only if every allele at every locus that occurs in one profile occurs in the other. A 'match' would then indicate that the suspect had been at the crime scene – in other words that the two samples have a common source, namely, the suspect. It does not always mean that the person actually committed the crime; it just indicates



DNA Laws and the status of DNA legislation South Africa

National DNA databases have been established in countries all over the world, as their enormous value to law enforcement is being recognised. In May 2012, Brazil became the 56th country in the world to pass DNA laws to regulate its DNA database. In South Africa, we are still in the process of elevating the status of our National DNA Database to an international level of acceptance. This will, if achieved, ensure that DNA evidence plays a key role in crime detection and prevention in a country which has one of the highest crime rates yet lowest rates of conviction in the world.

The existing DNA database in South Africa contains approximately 130 000 DNA profiles, the majority of which are crime scene (unknown) profiles. Compare this to the NDDs held by the USA (>10 000 000 million profiles) and the UK (>5 000 000 profiles) both of which contain a higher number of known or reference profiles than crime scene profiles, thereby allowing for a greater chance of a match or 'hit' when crime scene profiles are entered onto their NDDs. Furthermore, our DNA database has, through default, evolved under the governance of the *Criminal Procedure Act of 1977*, which was promulgated long before the advent of DNA profiling was used for crime resolution. It is however regarded as the legislative source for the current gathering of DNA evidence. Legislating policies and procedures to regulate a national DNA database for criminal intelligence purposes has become a matter of some urgency, not only because of the potential value of DNA as a law enforcement tool but also because of the civil liberties issues that these practices raise.

The expansion of the DNA database in South Africa is however only possible with the implementation of new DNA legislation, which will allow for the inclusion of all types of profiles on the NDD, as well as for comparative searches between crime scene and reference profiles. To this end, *The Criminal Law (Forensic Procedures) Amendment Bill B2-2009* was drafted and adopted by 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). Promulgation of this DNA Bill is expected to occur in early 2013.

Table 2: Legislation – International DNA databases

Country (year established)	Approximate number of profiles on DNA database	Removal criteria
UK (1995)	> 5 500 000	Never removed – under review
USA (1998)	> 10 000 000	Depends on State law
Germany (1998)	> 750 000	After acquittal or 5-10 years after conviction
China (2003)	> 5 500 000	No data
Canada (1998)	> 150 000	Convicted offenders never removed for primary offences
Netherlands (1994)	> 142 000	Convicted offender removed after 20-30 years
New Zealand (1995)	>100 000	Convicted offenders 10 years after release
South Africa (1998)	> 130 000	Inadequate legislation

that they were present at the crime scene and they would now be required to explain their presence at the crime scene. It is important to remember that DNA evidence is not the only form of evidence in a case and that other supporting evidence will still be needed by a court of law to convict a person of a crime. However, DNA is a very strong form of physical evidence and the technology used is exceptionally accurate and objective – DNA evidence doesn't lie!

If there is no match between the crime scene profile and the reference profile, then the samples may be considered to have originated from different sources. The term used to indicate that there is no match between two DNA profiles is an 'exclusion.'

In some cases, forensic analysts may report that a match has been 'inconclusive' or that it is a 'partial match'. A pair of profiles are said to be a 'partial match' if there are allelic matches at some of the loci. There may be several reasons for this type of inconclusive result or partial match. For example, contaminated samples often yield inconclusive results. So do very small or degraded samples, which may not have enough DNA to generate a full DNA profile. In such cases the court will not regard the DNA results from those samples as providing a large enough contribution towards the determination of whether the suspect was in fact at the crime scene and will look for other forms of evidence to prove the guilt or innocence of the suspect. A partial match may however help to exclude a suspect where none of the alleles at any one locus match.

Probabilities

Once a match has been identified between a crime scene profile and a suspect this information can be used as evidence to support the case presented by the prosecution in court. DNA evidence is always presented to a court of law in terms of a random match probability – this value will provide an indication to the court on how much 'weight' should be attached to an evidential item. For example, the report from the laboratory might describe an exact match between a semen sample found in the body of a rape victim and a blood sample taken from the suspected rapist. If the probability of another person (other than the suspect) in the South African population having the same profile is in the region of one in a billion, the court will consider this to be very valuable evidence, indicating that the suspect was in fact the source of the DNA found in the victim's body. On the other hand, if a probability of one in a thousand were reported then the court would not consider that item of evidence as compelling in terms of absolutely clearly linking the suspect to the alleged crime. Due to the fact that forensic scientists analyse at least nine ▹▹

Case report: the South African DNA database leads to the successful conviction of a serial rapist

On 6 June 2011 Shavani Phophi, known as the Muldersdrift rapist, was found guilty of six rapes, three robberies with aggravating circumstance, and two cases of theft. Five of the rape victims were adult women to whom Phophi offered work and then lured to Nooitgedacht to rape them in the veld. The Investigative Psychology Unit of the SAPS used a number of strategies, including DNA, to successfully link all the adult rape cases and to locate the suspect in his shack in KyaSands. After arrest the suspect was then also linked through the DNA database to the rape of a 10-year-old girl in 2005. Without the database, the case of the little girl would not otherwise have come to the attention of the police, because the other victims were adult females raped between June 2009 and May 2010. Phophi subsequently stood trial for all of these cases of sexual assault and received a combined sentence of two life sentences and a further 95 years behind bars.

Comparing the crime scene DNA to the reference DNA.

STR loci simultaneously, the chances of anyone other than the suspect having a matching profile are exceptionally small, making DNA a very strong form of evidence in criminal cases.

DNA databases: the key to criminal intelligence

A national DNA database (NDD) can be described as a repository of DNA profiles held by the government to identify suspects of crimes. The purpose of establishing and thereafter expanding a NDD is to provide the police with more useful criminal intelligence by linking DNA evidence found at crime scenes to unknown offenders, in much the same way as a fingerprint database works. This supports crime investigation and also reduction (where persons are convicted and prevented from committing further crime). If however, you exclude a DNA Database from the criminal justice system and only use DNA profiling on a case-by-case basis or as a prosecutorial tool, then DNA profiling falls short of being used to its full potential as a criminal intelligence tool. It is for this reason that countries throughout the world are embarking on extensive DNA database expansion programmes, as they realise the benefits of a NDD for crime resolution, detection and deterrence.

How does it work?

DNA profiles obtained from both crime scenes and suspects are entered into the NDD for comparative searching between the reference or convicted offender index (which contains profiles of known people) and crime scene profiles (unknown persons). In this way, a NDD provides valuable criminal intelligence to the police, because it can:

- identify the real perpetrator of the crime by comparing different crime scene profiles on the database to determine if there is a match
- link crimes where there are no suspects
- eliminate suspects where there is no match between the suspect and the crime scene profile
- determine whether there is a serial offender involved
- link a suspect, victim and crime scene/s.

For example, in cases where there is no known suspect in a case, the police will compare the crime scene profiles on a NDD with all the reference profiles stored on the NDD. If the perpetrator has been previously arrested or convicted of an offence then their profile may already be on the NDD, in which case a match would occur. In South Africa, where many criminals re-offend, this is extremely helpful in providing a 'lead' in a case. By helping to identify or rule out a suspect at an early stage in an investigation, a NDD also saves investigating officers valuable time which they can use to solve and prevent further crimes being committed.

Unfortunately, the South African DNA database is currently very limited in size and so is not used to its full potential. This is because our legislation does not allow for more DNA profiles to be loaded onto the NDD nor for the efficient management and regulation of the information uploaded onto the database. The database in its current form does not provide vital criminal intelligence that can be used to solve and prevent many of the heinous crimes committed daily in South Africa. The notorious criminal, Moses Sithole, is a case in point. He began raping women in his twenties, claiming three victims before one testified. He was sent to prison for six years. Shortly after his release in 1993 he embarked on a murder spree: in total he is known to have raped 40 women, 38 of whom were strangled with their own underwear. On 5 December 1997, he was sent to prison for 2 410 years with eligibility for parole in 930 years. If South Africa had kept his profile on a DNA database after his first release from prison in 1993, he could have been identified and apprehended after his first victim was raped and killed – 37 women's lives could have been spared!

The DNA Project

By now you will have understood that DNA profiling used in conjunction with a national DNA database is a reality that has fast become one the most powerful criminal justice tools used in the world today and is increasingly vital to ensuring accuracy and fairness in the criminal justice system. In South Africa, DNA evidence has been shown to have helped, and when used to its full potential, will continue to help solve and prevent some of the most serious violent crimes taking place here today. Before this can happen, current systems need to be reviewed, and some of them replaced, to ensure that we are fully able to utilise the benefits of DNA profiling as a crime-fighting tool.

The DNA Project, a non profit organisation was established in 2005 in response to this need in South Africa. It identified that the impact of DNA profiling in this country was limited due to a combination of factors such as inadequate legislation, insufficient laboratory capacity to meet the demands of an expanded DNA expansion programme, lack of awareness at the crime scene to preserve critical DNA evidence, outdated DNA databasing systems and a lack of specialised forensic DNA analyst skills. As a result of the lagging awareness by the government of the value and importance of an expanded DNA database the DNA Project's interventions include:

1. Creating greater awareness at the scene of the crime by educating people on the value of DNA and other forensic evidence as an evidential tool and the need to protect and preserve a crime scene to allow for the proper collection of all types of forensic evidence by qualified crime scene investigators. This is being done through a national crime scene awareness campaign which provides free DNA awareness workshops to first responding, non forensic crime scene personnel as well as the general public, paramedics and as members of the criminal justice system.
2. Developing a specialised forensic analyst honours degree at all tertiary institutions throughout South Africa.
3. Lobbying support for urgent changes in current legislation, which are needed to regulate the area of the law that relates to the use of DNA for the investigation, prosecution and resolution of crime.

Conclusion

The advent of DNA profiling and its use for identifying perpetrators of crime has transformed law enforcement investigations throughout the world, by allowing forensic laboratories to match suspects with minuscule amounts of biological evidence collected from crime scenes. The past two decades have seen extraordinary advances in DNA testing procedures, allowing investigators to test evidence collected from over 40 years ago with accuracy. The time needed to determine a sample's DNA profile has dropped from eight weeks to only a day or two – very soon the time needed to process samples may decrease to as little as a few hours. While the glossy laboratory environment, expensive cars and beautiful people capable of exacting a confession out of every suspect without the need for a court of law, which appear in *CSI*, are a far cry from reality, the possibility of collecting tiny amounts of biological evidence to link perpetrators to a crime scene is very real and is happening in the world – and South Africa – today. ❑

Vanessa Lynch, a commercial attorney, left her job in 2005, in order to run the DNA Project full time. Vanessa decided to stand up and be counted after her father was murdered during a robbery in 2004. Realising the vital role that DNA evidence could play in investigating crime, she gave up her career as an attorney and began lobbying to expand the existing DNA database in South Africa. Vanessa's legal background and her acquired skills in drafting and research, together with an innate determination and ability to 'think on her feet', are the ingredients required to fulfill the objectives of the DNA Project.

Carolyn Hancock has a PhD in genetics and was a genetics lecturer at the University of KwaZulu-Natal for 15 years. After watching an episode of Carte Blanche *in 2007 in which Vanessa spoke about the important work being undertaken by the DNA Project, Carolyn felt she could help in developing a postgraduate qualification in Forensic Biology. She contacted Vanessa immediately and subsequently became part of the DNA Project team. Her scientific knowledge, passion for teaching and desire to help make South Africa a safer place to live, have assisted the DNA Project in achieving its objectives in terms of developing skilled analysts for work at the forensic laboratory as well as educating people on the benefits of DNA evidence in crime detection and prevention.*

Definitions

Allele – A different form of a gene at a particular locus. The characteristics of a single copy of a specific gene, or of a single copy of a specific location on a chromosome. For example, one copy of a specific short tandem repeat (STR) region might have 10 repeats, while the other copy might have 11 repeats. These would represent two alleles of that STR region.

Cell – The smallest component of life capable of independent reproduction and from which DNA is isolated for forensic analysis.

Chain of custody – A record of individuals who have had physical possession of the evidence and the process used to maintain and document the chronological history of the evidence. (Documents can include, but are not limited to, name or initials of the individual collecting the evidence; each person or entity subsequently having physical possession of it; dates the items were collected or transferred; from where the item(s) were collected; agency and case number; victim's or suspect's name (if known); and a brief description of the item.)

Chromosome – The biological structure by which hereditary information is physically transmitted from one generation to the next. Located in the cell nucleus, each chromosome consists of a tightly coiled thread of DNA with associated proteins and RNA. The genes are arranged in linear order along the DNA molecule.

DNA (deoxyribonucleic acid) – Often referred to as the 'blueprint of life', DNA is the genetic material present in the nucleus of cells, half of which is inherited from each biological parent. DNA is a chemical substance contained in cells which determines each person's individual characteristics. An individual's DNA is unique except in cases of identical twins.

DNA analysis – The process of testing used to identify DNA patterns or types. In the forensic setting, this testing is used to exclude or include individuals as possible sources of body fluid stains (blood, saliva, semen) and other biological evidence (bones, teeth, hair). This testing can also be used to indicate parentage.

DNA profile (sometimes referred to as a DNA fingerprint) – The result of determining the relative sizes of repeated DNA sequences at several locations on an individual's chromosomes. Each person (except identical twins) has a unique DNA profile and DNA profiling can thus be used to discriminate between unrelated individuals, such as in the context of the National DNA Database.

Electrophoresis – A method of separating large molecules (such as DNA fragments) from a mixture of similar molecules. An electric current is passed through a medium and molecules separate according to their electrical charge and size. Separation of DNA markers or fragments is based on these differences.

Elimination/reference samples – A term used to describe a sample of known source taken for comparison purposes. An elimination sample is one of known source taken from a person who had lawful access to the crime scene (e.g. blood or cheek (buccal) swabs for DNA analysis, fingerprints from occupants, tire tread impressions from police vehicles, footwear impressions from emergency medical personnel) to be used for comparison with evidence of the same type.

Evidence – Something that can help to identify the persons responsible for a crime, items used to establish an element of crime or to reconstruct crime events or link crimes.

Evidentiary samples – A generic term used to describe physical material/evidence discovered at crime scenes that may be compared with samples from persons, tools, and physical locations.

Exclusion – A DNA test result indicating that an individual is excluded as the source of the DNA evidence. In a criminal case, 'exclusion' does not necessarily equate to 'innocence'. This occurs when one or more types from a specific location in the DNA of a known individual are not present in the type(s) for that specific location in the DNA obtained from an evidence sample.

Gene – The basic unit of heredity – a functional sequence of DNA in a chromosome.

Genetic loci – Specific locations in the genetic material of an organism where certain DNA sequences can be found.

Genotype – The genetic constitution of an organism, as distinguished from its physical appearance (its phenotype). The designation of the two alleles at a particular locus in one individual is referred to as their genotype.

Polymerase chain reaction (PCR) – A process used in DNA identification testing in which one or more specific small regions of the DNA are copied using a DNA polymerase enzyme so that a sufficient amount of DNA is generated for analysis.

Polymorphism – Variations in DNA sequences in a population that are detected in human DNA identification testing.

Random match probability – The probability that the DNA in a random sample from the population has the same profile as the DNA in the evidence sample.

Recidivism – A tendency to relapse into a previous condition or criminal behaviour.

Reference samples – A standard/reference sample is material of a verifiable/documented source which, when compared with evidence of an unknown source, shows an association or linkage between an offender, crime scene, and/or victim (e.g. a carpet cutting taken from a location suspected as the point of transfer for comparison with the fibres recovered from the suspect's shoes, a sample of paint removed from a suspect vehicle to be compared with paint found on a victim's vehicle following an accident, or a sample of the suspect's and/or victim's blood submitted for comparison with a bloodstained shirt recovered as evidence).

Short tandem repeat (STR) typing – DNA analysis method which targets regions on the chromosome which contain multiple copies of an identical DNA sequence in succession.

Short tandem repeats (STR) – Multiple copies of a short identical DNA sequence arranged in direct succession in particular regions of chromosomes.