



INTERPOL

INTERPOL HANDBOOK ON DNA DATA EXCHANGE AND PRACTICE

RECOMMENDATIONS FROM THE
INTERPOL DNA MONITORING
EXPERT GROUP

SECOND EDITION 2009

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INTRODUCTION

BY RONALD K. NOBLE
THE SECRETARY GENERAL OF INTERPOL

Globalization and advances in technology allow criminals to commit crimes across international borders with greater ease than ever before. With criminal methods and tactics changing continuously, the tools used to fight crime also need to keep pace. One area where cutting-edge developments have emerged is that of the use of DNA evidence, meaning that ethics and best practice of DNA profiling now need to be addressed on a global scale. At INTERPOL, we are doing just that; assisting the law enforcement and forensic community by supporting, facilitating, and promoting the use of DNA analysis on a national, regional and international level.

In order to meet the growing need for INTERPOL member countries to exchange and compare DNA profiles, we have developed several DNA data-sharing tools, known collectively as the INTERPOL DNA Gateway. These include an international DNA Database, an international search request form for bilateral exchange and a means for secure standardized electronic transfer. Since the introduction in 2003 of the INTERPOL DNA Database, over 50 member countries have contributed profiles for international searches and storage. This number is remarkable given that today no more than 54 member countries operate a national DNA Database. However, these tools cannot function in isolation, which is why we back up our high-tech data exchange systems with promotional workshops, DNA conferences and resources such as this publication.

The INTERPOL Handbook on DNA Data Exchange and Practice was first published in 2001. Translated into seven different languages, and available via the Internet and several intranet channels, it has become popular with investigators all over the world. Since its initial publication, the number of national DNA Databases in existence has more than doubled, and techniques, standards, applications and experiences in all fields relating to DNA profiling have changed considerably. In response, the INTERPOL DNA Monitoring Expert Group has reviewed and updated the Handbook, with the aim of providing state-of-the-art recommendations to police and forensic science services and maximizing the benefits of using DNA profiling techniques worldwide. It is our hope that this handbook will help define global standards in relation to DNA profiling and will further enhance the capabilities of INTERPOL member countries.

Lastly, I would like to thank everyone who has contributed to this manual, making it an essential reference for investigators across the world, and to encourage any feedback. Your comments, experience and professional insight will help us keep the INTERPOL Handbook on DNA Data Exchange and Practice as up-to-date and relevant as possible.



This handbook aims to highlight the importance of the use of DNA in police investigations by demonstrating the use of DNA in a fictitious case and also by addressing the factors affecting DNA profiling and databasing in the world today.

The handbook is in two main parts, with the first covering an investigation all the way from the murder scene at an international airport to the successful arrest of the perpetrator after extradition. Practical elements of the case, including DNA sampling and evidence collection and the procedure to be followed, are addressed and can be seen to serve as guidelines for best practice policy. There are also chapters in this section dedicated to the work done in the laboratory, showing the stages of DNA analysis that are undertaken before it can be used as evidence. At the end of this section is a case conclusion, using the example of an international criminal taking advantage of the freedom of travel to commit his crimes. There is then a sub-section, entitled DNA Investigation Considerations; this includes chapters on media relations, quality assurance and training with regard to an investigation using DNA. This section aims to highlight the value of DNA evidence, efficient best practice guidelines and international communication to ensure that dangerous criminals are apprehended even when they cross national borders.

The second part of this handbook concentrates on the factors that affect the use of DNA evidence in police investigations, including DNA Databases, legislation and privacy concerns. A global overview of DNA Databases is given to demonstrate the number of countries using this investigative tool and the value of a national DNA Database. Finally, this section aims to address the scientific aspect of DNA evidence and its potential with a description of post-conviction testing, familial and geographical searching and the issues raised when using DNA evidence in this way.

Note: This document is also available on the INTERPOL website and relevant sections, such as training and references will be updated electronically in the web-based version.

● BACK TO BASICS: THE USE OF DNA IN CRIMINAL INVESTIGATIONS

During the commission of a violent crime, it is reasonable to expect that body fluids such as blood or semen will be transferred between the victim, the suspect and the crime scene. This concept of “Every contact leaves a trace”, the cross transfer of physical evidence, was first stated by Dr Edmond Locard, who was Director of the first crime laboratory in Lyon, France, in the early 20th century. This statement became known as Locard’s Exchange Principle, and established the foundations of forensic science. Physical evidence recovered from the crime scene can be used to associate an individual with the crime (for example through DNA profiling or fingerprints). It is also possible to reconstruct the events of the crime through techniques such as blood pattern analysis and other crime scene reconstruction techniques. It is the decision of the investigating officer to identify the need for forensic examination and the responsibility of trained forensic personnel to successfully recover this physical evidence from the crime scene, undertake the subsequent scientific examination and report the results of the analysis as a statement of evidence or as court testimony.

DNA can be used as evidence due to a few basic scientific facts.

DNA is present in every cell (excluding red blood cells) and for the purposes of DNA profiling is unique to every individual (except identical twins). The analysis of cells left at a scene allows for the DNA present to be profiled and a unique sequence for a particular individual to be determined (*see Appendix 3 for detail*). Cells containing DNA can be found in many different sources of biological evidence (*see DNA sampling and evidence collection*).

● WHY IS FORENSIC DNA PROFILING IMPORTANT FOR LAW ENFORCEMENT?

DNA profiling first achieved public recognition in 1987 when it was used in a high-profile case where DNA evidence led to the successful conviction of a dangerous sex offender and the exclusion of an innocent suspect. The continual emerging strength of DNA profiling is its ability to allow a large number of samples to be compared with a high degree of reliability. The profiling techniques being developed fit more closely with standard specifications and are more applicable to the routine analysis of crime scene samples, often obtained from high-volume crime. The increasing number of DNA profiles that are sent for comparison has required the development of DNA Databases so that we are able to accurately and efficiently match and manage the data.

INTERPOL DNA UNIT AND MONITORING EXPERT GROUP

● ORIGIN

The INTERPOL DNA Unit was established at the General Secretariat in Lyon in March 2000 in response to demands by many of INTERPOL's 188 member countries. The primary project was to establish a group of experienced external advisors to work with INTERPOL to implement international best practice guidelines and international DNA data exchange, thus creating the INTERPOL DNA Monitoring Expert Group (MEG). The Monitoring Expert Group is a panel of forensic experts and senior investigators which advises INTERPOL and encourages authorities in member countries to implement or expand national databases. It also aims to standardize collection efforts and to promote accreditation criteria for forensic laboratories to ensure the integrity of samples. With their support and guidance INTERPOL has so far managed to achieve the following:

- recommendation of the ISSOL (INTERPOL Standard Set of Loci) worldwide (see *Appendix 1*). This standard was created to encourage countries to use a core set of loci that would facilitate international comparison. The ISSOL also allows for the identification of individuals but not for the extraction of personal information, apart from gender.
- establishment of the INTERPOL DNA Gateway
- development of the INTERPOL DNA Database
- installation of the G8 I-24/7 DNA SRN (Search Request Network for laboratories in G8 countries)
- management of 19 DNA MEG meetings
- organization of five International DNA Users' Conferences for Investigative Officers
- arranging seven regional DNA workshops or conferences
- performing three global DNA Surveys
- publication of the INTERPOL DNA Handbook, Training DVD and DNA survey Reports
- issuing advice for criminal investigations under the UN Mandate
- providing assistance to DNA-led international Disaster Victim Identification operations.

INTERPOL proactively promotes DNA profiling as a highly valuable and relatively economical forensic identification tool and by doing so has increased the interest in this investigative support technique around the world, in particular in developing countries and regions.

● THE DNA DATABASE

The INTERPOL DNA Database was developed in 2002. According to the latest Global DNA Survey, 54 member countries are operating national DNA databases, with 54 countries currently populating the INTERPOL DNA Database. The DNA Database is used in police investigations to search a DNA profile against all other international profiles that have been submitted for unsolved crime stains, convicted offenders, suspects, unidentified bodies and missing persons. Each country retains ownership of its profile data and controls its submission, destruction and access by other countries in accordance with their national laws.

In respect of data confidentiality, an important parameter in the INTERPOL DNA Database is that profiles are searched without the name of the person to whom the profile belongs. When there is a database match, the countries concerned are informed and invited to co-operate bilaterally should they choose to pursue the investigation. This procedure ensures that only when there is a match in the INTERPOL DNA Database will the identification and circumstances of the suspect be revealed between the countries concerned, should they so decide. Also, to ensure the quality, and therefore reliability of DNA profiles, countries must declare if the DNA profile was produced in an accredited laboratory.

Access to the DNA Gateway is provided directly to a country via the INTERPOL National Central Bureau (NCB) using INTERPOL's I-24/7 secure police communications system. Member countries also have the technical possibility for direct access to the database from the NCB or another authorized entity such as a national forensic institute.

● DNA GATEWAY SUCCESS STORY

On 31 January 2006, four individuals committed an armed robbery in a jewellery store in Vaduz, Liechtenstein, leaving with merchandise and cash with a value of more than one million Swiss Francs, approximately EUR 620,000. One suspect was arrested but managed to escape from the Vaduz prison on 19 July of the same year with the help of two men, one of whom is suspected of having taken part in the armed robbery.

Following these events and investigation by the Liechtenstein Police and INTERPOL's National Central Bureau in Vaduz, the NCB issued diffusions (alerts to countries), and later requested the issuance of INTERPOL Red Notices, or international wanted persons alerts, for four individuals, three of them from Serbia and one from Croatia. The Police provided photographs, fingerprints and DNA profiles for each of the four wanted individuals. This information was stored in INTERPOL's databases and is accessible by 188 member countries.

Less than a year later, on 19 April 2007, INTERPOL received 14 DNA profiles from the United Arab Emirates Police in relation to an armed robbery in a jewellery store in Dubai, United Arab Emirates. They requested an urgent check against INTERPOL's DNA Database.

Analysis conducted at the INTERPOL General Secretariat in Lyon, France, immediately revealed that two of the profiles sent by the United Arab Emirates matched those of two of the four men wanted by Liechtenstein for the robbery that had occurred on 31 January 2006. One other profile matched a profile from an unknown individual collected at the scene of an armed robbery committed at a jeweller's on 22 April 2005 in Switzerland and shared with INTERPOL by the Swiss Police.

Further investigation conducted by INTERPOL in co-operation with several of its member countries revealed that all three individuals were part of an organized crime group, referred to as the Pink Panthers, which specializes in armed robberies of jewellers and which had already hit 17 countries in Europe and elsewhere.

By using DNA evidence, the INTERPOL DNA Database and the investigative powers of the INTERPOL member countries, three members of this gang have already been arrested and charged with numerous international offences, thus emphasizing the effectiveness of this forensic tool and its use in the fight against cross-border crime.

PART I: CASE SCENARIO

FICTITIOUS SCENARIO

● INTRODUCTION

This scenario puts the use of DNA in investigations at an international level into context. In this scenario details will be given about a rape and murder that occurred at Vienna international airport (VIA) and the evidence that was present at the suspected scene of the crime. In many ways this scenario is applicable to a variety of crime scenes that use DNA profiling to help bring the perpetrator to justice. The following chapters will address the issues involved in an investigation of this nature. They aim to offer advice on best standard practice and guidelines on procedures by demonstrating the best approach for the crime committed at VIA. Accompanying this best approach there are also some general points for reference, however the most important thing to remember is that each crime scene is different and each approach will be unique. The best way to approach such investigations is with careful consideration for all possibilities and by looking to apply the most accurate and up-to-date information possible.



Picture 1 – Vienna International Airport

● DISCOVERY OF THE BODY

At 06.00 on Monday 17 April, the transit cleaning supervisor arrives at work and walks along the corridor to the store room. Everything appears normal as he walks past the toilets.

He pauses to reach for his keys from his coat pocket and looks to the store room door. Unusually, the door is closed but it is not secure. Looking more closely he can see signs of force to the side of the lock and notices fragments of wood and paint on the floor.

He cautiously pushes the door open and looks into the darkened room. The light from the corridor illuminates the first metre inside the door but he does not enter. Reaching around the door frame to his left he feels along the wall at chest height attempting to locate the light switch. The lights flicker and then illuminate the room, he looks around.



*Picture 2 - Entrance to the female toilet area
and access to the male toilet area and the storage room*

The room is quite small, approximately three square metres, and contains a sink and taps on the left-hand wall and has four lockers against the back wall. To the right are three armchairs all facing towards the door. Finally in front of the chairs a rubber-backed grey mat covers the cold tiled floor.

Although he immediately recognizes his surroundings his eyes are drawn to the mat and the body of a female lying lifeless before him. The figure is positioned before him on her back, with her head against the chair leg and her right arm above her head beneath the chair. Her head is turned away from the door and her long blonde hair covers her face.

Her clothing is disturbed. She is lying on her three-quarter length cream coat which she is still wearing. A knee-length black skirt is pushed up towards her waist and white underwear is secured around her left knee. Her white top is torn and reveals her midriff.

Her right shoe remains on her foot and the left foot lies behind the door which is now open and close to her handbag.

Using his pocket radio the supervisor calls his control room to inform them and request police attendance at the scene. It is now 06.05.

● POLICE ARRIVAL AT THE SCENE

Having received a radio message about a forced store room door, a young police officer walks through the airport to the East Pier Transit lounge arriving at 06.10.

The supervisor has already placed cones across the corridor to stop passengers entering this area leading to the toilets. On seeing the officer he rushes towards him and starts to explain what he has just discovered. The two men walk quickly along the corridor to the open store room door. The supervisor still remains reluctant to enter the room and instead guides the officer through the doorway.

Inside the room the officer looks around to make an assessment of the scene. He walks to where the body lies and kneels down to the left-hand side.

Carefully taking hold of the victim's left wrist, he feels for a pulse. The hand is cold and lifeless and no pulse is located. He looks towards her head and notices a red silk scarf tied around her neck.

He stands up and backs away from the body taking a mental note of the disturbed clothing. He believes the victim has been raped and murdered within the confines of the room which is now considered to be a murder scene.

The responding officer instructs the supervisor to secure the end of the corridor and ensure no one enters the area until further assistance arrives. He then confirms the details of the incident with his control room and requests supervision and crime scene examiners to attend the scene.

● MEDICAL EXAMINATION

The medical examiner arrives at the scene with other CSI personnel and accompanying police officers and enters the store room to examine the body. Having noted all injuries and marks to the victim he pronounces life extinct and estimates that the victim was killed at least five hours before being found. The murder, therefore, occurred during the previous night. At this moment in time it appears that the most likely cause of death was strangulation. This assumption is made due to the bruises around the victim's neck and is later confirmed by autopsy results.

● INVESTIGATION OF THE SCENE

Crime scene examiners then conduct a full forensic examination of the scene and photograph the corridor, storeroom, door and body. No fingerprints or other physical evidence are found within the scene area at this time. The room and corridor are not covered by the airport CCTV system.

The only obvious item of evidential value to the investigation other than the body at this time would appear to be the item of underwear. This item would usually not be removed from the victim at this time. The body and items of clothing including the underwear are secured in a body bag and transferred to the appropriate mortuary facility for full examination by both the Pathologist/Coroner and the crime scene investigators.



Picture 3 - Transit area Pier East VIA

● MAIN ENTRANCE ROUTE TO THE CRIME SCENE

A long corridor stretches away from the main seating area with clear overhead signs indicating toilet facilities and an emergency exit. The corridor is well lit with fluorescent strip lighting overhead.



Picture 4 - Corridor



Picture 5 - Entrance to the toilets

Approximately 20 metres ahead on the right-hand side is the doorway and entrance to the toilets.

A further 15 metres beyond the door is the access to the female toilet facilities, which are located on the left-hand side through another door.

To the right, the corridor extends straight ahead. Twenty metres on the left are the male toilet facilities and straight ahead is the storage room also used by cleaning staff. Finally, to the right, opposite the male toilet door, is the corridor leading to a set of double secured fire doors giving access to a fire escape.

INVESTIGATIVE APPROACH TO THE FICTITIOUS SCENARIO

● PROCEDURE

Examination of the scene:

The first police officer at the scene should make a very limited examination and evaluation of the scene. Care must be taken to avoid destroying existing evidence. The police officer should be satisfied that the extent of the scene has been correctly identified and should enforce boundaries to ensure no potential evidence is compromised or lost.

The following expert assistance should be requested in this order:

1. Crime scene investigators and, when needed, a doctor to confirm death.
2. Forensic examiner
3. Senior police officer (SIO)
4. Other experts if necessary

Examination of the toilets:

The victim may have been attacked within the toilets and then moved.

The offender may have entered the toilets following the attack leaving evidence in the toilets after the rape. Questions to begin to consider include: Does other circumstantial evidence exist? Does the information available suggest any specific kind of *modus operandi*?

Examination of DNA evidence:

Urgent analysis of all samples from the autopsy is vital, so that the offender's DNA profile can be recovered as soon as possible. Confirmation of the existence of a DNA profile of the offender could prove essential for the investigation process.

● ASKING THE RIGHT QUESTIONS

Introduction - Description of the transit area:

- How many areas are there like this within the airport?
- Are they identical?
- How easy or difficult is it to move from one transit hall to another?
 - for passengers
 - for airport staff
- Which specific flights leave from this transit hall?
- Has all relevant information about passengers and staff with access to this area been recorded?
- Consider warning the police at all possible destinations to check the passengers when they arrive (How much time has elapsed since the death?). This could be a difficult and time consuming task.

- Consider physical evidence that may be left on aeroplanes or at destination airports.
- Identify all surveillance (CCTV) cameras and secure all tapes or images.

Scenario:

The cleaning supervisor – who is he? Obtain all relevant information about his background.

- Should he be on duty at this time?
- Everything appeared 'normal' – What is normal for the cleaning supervisor?
- Examine and collect any fingerprints or DNA, footprints/shoe marks, samples from the scene.
- Consider– reference/elimination samples from the supervisor.
- Is there any reason to collect his clothes?
- Consider legal issues, is the supervisor a witness or suspect at this time?

The Body:

- Cause and time of death?
- Any distinctive features that may aid identification?
- Any further identifiable evidence about the crime or the perpetrator?

The Victim:

- Who is she?
- Is she airport staff?
- Is there an ID-card present?
- Is her clothing a uniform?
- Does the victim have any keys for the room?
- Is she a passenger?
- Is there any unattended luggage left nearby?
- Any flight or identity documents?
- Is anyone missing from a recent flight?
- Does she have a mobile telephone?
- Is the victim seen on any CCTV and was she with anyone?

When the body is formally identified we must confirm all the relevant information about the victim, and ascertain whether there is any property missing.

Can we identify any apparent connection to the cleaning supervisor?

Information relating to the scene, the body and all persons known to be associated with the circumstances or area should be considered in the context of forensic (DNA) examination as all could require processing for evidentiary or elimination purposes.

(For more questions for consideration when using DNA in investigations see Appendix 4)

When dealing with an investigation of this nature, effective management is critical in ensuring the efficient utilization of police and laboratory resources. The management of DNA cases should target the collection of evidence from the scene, evidence submission policies and a holistic scientific approach that takes into account the probative value of all the available physical evidence. Such case management policies are especially important in criminal investigations requiring intelligence-led DNA screening as part of the investigative process.

● POLICIES FOR POLICE DNA CASE MANAGEMENT

Rapid innovative changes in the field of forensic DNA profiling make consultation with the DNA expert/laboratory an integral part of the investigative process of any case. It is advisable for police investigators or prosecutors to contact the forensic specialist to discuss what DNA technologies currently exist for the examination and testing of the biological evidence connected with their case.

The effectiveness of DNA profiling can be compromised by chemicals and contaminants and these may influence which type of scientific analysis is to be used. Consequently, investigators, in collaboration with the scientist, must evaluate the available physical evidence to determine which scientific analysis will provide the court with evidence of the highest probative value. For example, the decision to process the scene for fingerprints or swab for DNA evidence requires knowledge of both the effect of the fingerprinting process on DNA and the probability of successfully recovering DNA from an item.

There are documented case management guidelines for:

- DNA Evidence Recovery based on an understanding of the potential value of the evidence and its impact on and ability to assist a case. The effective recovery of DNA evidence from the crime scene is achieved when officers are well informed of the evidentiary potential of DNA and trained in DNA evidence recovery (see *DNA Sampling and Evidence Collection*).
- Appropriate packaging and preservation of DNA evidence that maintains its integrity and prevents contamination (see *DNA Sampling and Evidence Collection*).
- Comprehensive documentation and case details to assist in the laboratory analysis process and demonstrated chain of custody requirements based on legal requirements (see *In the Laboratory*).
- Evidence submission based on clear investigative objectives as dictated by the circumstance of the case. Submission policies are especially valuable in cases involving large numbers of exhibits and serve not only to efficiently allocate resources but also to focus the scientific and criminal investigation.
- An effective case management policy will directly impact the forensic analysis by allowing the scientist to target those exhibits that yield evidence of the highest probative value, select the most appropriate DNA techniques and complete the analysis of the cases in the most efficient manner.

DNA SAMPLING AND EVIDENCE COLLECTION

The most important aspect of evidence collection and preservation is protecting the crime scene from the time the first officer or responder arrives until the last piece of evidence has been noted and collected. This section will cover the procedures for the first responder to a crime scene, preservation of the scene, actions of the Crime Scene Investigator (CSI), valuable kits to process DNA evidence, the collection of evidence and anti-contamination guidelines. The administration and transportation requirements of DNA evidence are also addressed.

All biological evidence is subject to deterioration. Careful collection and storage will ensure that this evidence is preserved so that useful information can be obtained from its analysis. Most DNA typing methods are robust; however, dirt, grease, some dyes in fabrics, and other substances can seriously compromise the DNA typing process.

The advice given applies to the investigation of all crimes where body fluids are deposited, such as sexual offences, robberies, burglaries, etc. A crime scene log or sign-in sheet should be used to record who enters the area and the time of entry and exit. In addition, all crime scene personnel must wear protective clothing, hairnets, gloves, paper boots, and masks. Because of the ease with which DNA contamination can occur, the first police officer should meticulously record the identity and actions of those who have already been to the scene and anyone else who may pose a post-incident contamination risk.

● FIRST RESPONDERS

Taking the Initial Call

The actions of the cleaning supervisor and first responding officer in the scenario clearly demonstrate the actions that should be taken to efficiently preserve the scene. The scene should be secured as soon as possible so that only the people responsible for the crime investigation have access. Any other individuals or unescorted personnel can introduce contamination and disrupt the crime scene. The area can be secured using ropes, tape, cones, barricades, or even additional officers. The administration and transportation requirements are also addressed.

Crime Scene Preservation

The first officer should:

1. Find out when the CSI will arrive and inform the individual concerned.
2. Take care not to contaminate the scene.
3. Gather as much information as possible from the victim(s) or witness(es) without disrupting potential evidence.
4. Consider health and safety risks and ensure the victim and other personnel are not placed at risk from body fluids, broken glass, sharp objects, damaged electrics, poor lighting conditions, leaking gas or agitated victims, witnesses or suspects, etc.
5. Remember this does not affect an officer's first responsibility to preserve life.

Personal Protection Guidelines

- All body fluids should be regarded as potentially infective.
- Cover any cuts or grazes on hands with waterproof dressings and gloves.
- Wash hands often, especially when beginning or ending a new task, before break or meal times, before smoking, and at the beginning and end of duty periods.

It is recommended that CSIs should always attend if the first officer in attendance determines that the crime involves:

- Violence, robbery, or a crime of a sexual nature.
- The burglary of a dwelling, including distraction type burglary offences when the victims are vulnerable.
- Any other offence where there is visible physical material to be recovered, for example:
 - glass is broken
 - window has been opened by an offender
 - a door has been forced/removed
 - items have clearly been handled/moved
 - footwear marks are present and visible
 - body fluids are evident
 - hair samples are present
 - part eaten food/cigarettes butts or drink cans are evident
 - any other alien material has been brought to the scene by the offender
- It is desirable for the officer first attending and the CSI to speak to one another by telephone if circumstances allow.



CRIME SCENE INVESTIGATOR (CSI)

When the CSI arrives at the scene, the actions of the first responder and the first attending officer will determine how much evidence they are able to collect. A CSI should be trained in evidence collection (see *Training*) and be knowledgeable in the types of evidence present that can help to convict a suspect.

In this scenario, it is difficult to locate evidence due to the area surrounding the scene. It is impossible to determine how many people have walked down the corridor and left trace evidence, and therefore it is difficult (if not impossible) to single out evidence that was left by the perpetrator. In this particular scenario, no fingerprints or footprints could be identified, so the most valuable evidence is the clothing and the body itself. A medical examination will be carried out and the underwear will be analysed for the presence of DNA and trace evidence (e.g. hairs, textile damage, fibres). It may also be possible to take a swab of the door handle and obtain a DNA profile using state-of-the-art DNA techniques (see *In the Laboratory*).

However, each crime scene is different and there are many types of biological evidence that can be present. Biological evidence can be transferred to an individual's body or clothing or to an object or crime scene directly. Once liquid biological specimens have been deposited, they become stains and adhere to the surface or the substrate. Non-fluid biological evidence, such as tissue, bone or hair, can also be transferred by direct contact and deposit. There are hundreds of varieties of physical evidence commonly submitted for examination to forensic science laboratories. Evidence that could be subjected to DNA analysis is generally limited to things that are biological in nature. The following table consists of biological materials from which DNA has been successfully isolated and analysed:

Table 1: Biological materials and how DNA can be isolated and analysed

BIOLOGICAL MATERIALS	HOW TO ISOLATE AND ANALYSE FOR DNA
Blood	Blood may be found in the form of pools, drops, splashes and smears. It may be flaked, liquid or dried.
Bone	Bone samples of badly decomposed bodies can be used for DNA analysis.
Dandruff	Certain skin complaints result in excessive amounts of scalp and skin tissue that may be suitable for DNA analysis.
Hair(s)	DNA is contained in the hair root and in any scalp cells surrounding the root of a plucked hair. A single plucked head hair may have sufficient cellular material attached for DNA analysis. In contrast, naturally shed hairs, as often found on clothing, do not normally have sufficient DNA material associated with them for analysis. It is difficult to assess the quality of a hair root without examining it under a microscope, therefore all hairs shall be collected.
Hair shafts	There is no DNA in hair shafts suitable for standard STR profiling, although mitochondrial DNA analysis can be used on pieces of rootless hair.

Table I (continued)

BIOLOGICAL MATERIALS	HOW TO ISOLATE AND ANALYSE FOR DNA
Faeces	Standard methods of DNA analysis are unsuitable for analysing faeces, unless mixed with blood, but mitochondrial DNA analysis can be used.
Fingernails	A DNA profile can either be obtained from the skin and blood cells that can gather under a nail, if a victim scratched the attacker; or from the actual fingernail as the nail contains sufficient quantities of DNA for analysis.
Fingerprints	It may be possible to obtain a profile by swabbing the residue left behind after retrieving a fingerprint and then examining it using the LCN DNA analysis technique.
Flesh	Pieces of flesh may be encountered where an individual has been injured. This type of sample will contain large quantities of DNA and will be suitable for analysis.
Nasal or ear secretions	Used handkerchiefs and cotton swabs where there are obvious nasal or ear secretions, may be a good source of DNA.
Parts of bodies	Parts of bodies are sometimes encountered at scenes, often in poor condition. However, there is still the potential for DNA analysis.
Saliva	Saliva staining may, or may not, be visible. There is no DNA in saliva itself, but DNA is present in the mouth cells that are shed into the saliva.
Semen	Semen may be found as a liquid (e.g. in a condom) or as visible staining. It may also be present but not visible and its possible location may have to be assumed when deciding what items to submit to the laboratory. Liquid semen and even very small semen stains usually contain many sperm, each of which contains DNA. Even where the semen contains no sperm there may still be sufficient cellular material for DNA analysis.
Skin cells	It is possible, through touching or handling objects or by wearing garments, that a person's DNA will transfer from the donor to the object or garment. This is sometimes referred to as 'contact trace DNA'. Whether it is likely to be found varies considerably on the circumstances but it can be considered for probative objects in serious cases.
Sweat	This is a liquid secretion and contains no DNA material. In cases where laboratories have been successful in obtaining DNA from sweat-stained areas on clothing, this has been attributed to the coincidental presence of cells.
Urine	Urine may contain cells from the lining of the urethra, although it is unlikely that there will be enough cells for DNA analysis.
Vaginal fluid	Vaginal fluid will contain cells from the lining of the vagina and is suitable for DNA analysis.



POTENTIAL SOURCES OF DNA

There are many different items that can provide a source of DNA evidence. Below is a list of possible sources:

Table 2: Potential DNA sources

EVIDENCE	POSSIBLE LOCATION OF DNA ON THE EVIDENCE	SOURCE OF DNA
Bite mark	Person's skin or clothing	Saliva (mouth cells)
Blanket, pillow, sheet	Surface area	Blood, dandruff, hair, saliva, semen, sweat, urine and/or vaginal fluid
Bottle, can, glass	Sides, mouthpiece	Fingerprint, saliva and/or sweat
Dirty laundry	Surface area	Blood, dandruff, hair, semen and/or sweat
Door knobs	On the handle	Fingerprints, skin and/or sweat
Spectacles	Nose or ear pieces, lens	Skin and/or sweat
Facial tissue, cotton swab	Surface area	Blood, nasal or ear secretions, semen and/or sweat
Fingernail	Under nail or attached to it	Blood, flesh and/or sweat
Hat, bandanna, mask	Inside	Dandruff, hair and/or sweat
Stamp of envelope	Licked area	Saliva
Tape or ligature	Inside/outside surface	Fingerprints, skin and/or sweat
Recovered bullet	Outside surface	Blood and/or flesh
Toothpick	Tips	Saliva
Used cigarette	Cigarette butt	Saliva
Used condom	Inside/outside surface	Faeces, rectal cells, semen and/or vaginal fluid
Weapon, e.g. baseball bat, knife, etc	Handle, end	Blood, fingerprints, flesh and/or sweat

This is not an exhaustive list; any item that has been handled is a potential source of DNA.



DNA SAMPLING KITS

This next section will outline the suggested contents of DNA sampling kits and how to use them. Care must be taken at all stages to avoid contamination and ensure that the sample collected is packaged and labelled correctly.

Crime Scene Stain/DNA Sampling Kit

A scene of crime stain sampling kit contains at least the following items:

- Documented check-list
- Instructions on the use of the sampling kit
- Breathable tamper-evident bags/containers and/or cardboard packaging, which have a unique number or barcode
- Sterile (self wetting) swabs (extra swabs available if necessary)
- Sample/vial of sterile water
- Pair of disposable gloves
- 1 x Form/label with relevant information about the sample (chain of custody)
- The contents of a scene of crime sampling kit are to be used for collecting biological stains as previously stated

Procedure for Stains

Liquid Samples

If blood, semen or saliva is present as a liquid or wet stain, it should be collected using dry swabs or pipettes (if available). Sterile cotton wool swabs are suitable for collecting crime scene samples. The sample should be collected on one area of the swab and not smeared over the whole surface of the swab head.

Dried Stains

Visible stains can be collected in a number of ways. It is always preferable to recover an item in its entirety. Where this is not possible stains can be recovered in a number of ways:

- Swabbing – moisten a swab with a very small amount of sterile water so that the swab is only moistened and not wet and use the swab to rub the DNA material concentrating the sample on as small an area as possible
- Scraping – scrape the dried stain from the surface with a disposable sterile scalpel blade and place the flakes in a suitable sterile container or in clean folded paper.
- Cutting – use a sharp sterile blade to cut out the surface bearing the DNA material, for example, wood and wallpaper.
- Lifting – using adhesive tape the stain is lifted onto the sticky side of the tape which is then placed sticky-side down onto a sterile surface such as an acetate sheet. This can make a clean lift of the stain which is then preserved under the tape.

In all circumstances, it may be relevant to also take a control sample.

The person taking the sample must wear the gloves provided throughout the whole sampling procedure. Masks should be worn, especially if suffering from a cold or if close examination of the surface or stain is required.

Open the sampling kit and ensure that the kit is complete by checking off each item against the check-list provided.

Once the sample has been collected using one of the methods described above, place it in the swab container and/or the small breathable tamper-evident bag provided. Seal the bag and record crime scene details on the chain of custody form/label (use unique numbered seals/bar codes and/or police references). It is of critical importance that each sample is individually packaged so as to prevent any opportunity for sample-to-sample cross contamination.

If at any time during the sampling process the sample (e.g. swab) is dropped or comes into contact with any other surface, ideally the procedure should be stopped, the sampling kit disposed of and samples taken using a new DNA sampling kit. However, since it is likely that only small amounts of crime stains are present, then the exact chain of events should be documented and submitted together with the sampling kit.

Once the samples have been successfully taken, place them in a large tamper-evident bag, store, and forward to the laboratory as per legal or police force instructions

Collect the wrappers and gloves and dispose of them using designated receptacles.

Sexual Offences Medical Examination Kit

A sexual offences medical examination kit needs to contain at least the following items:

- Instruction booklet
- Breathable evidence bags/ containers which are unique-numbered or bar-coded
- 1 x large sheet of paper in a polythene bag
- Pair(s) of disposable gloves
- Plain sterile cotton swabs
- Cocktail sticks in small self-seal polythene bags for fingernail scrapings
- Combs in polythene bags for hair combings
- Self seal bags (for swabs, hair samples, blood and saliva bottles etc)
- A form with relevant information on the victim or suspect
- Packaging material for clothing should be made available by the police

The contents of sexual offences medical examination kit is for police surgeon or general medical officer use only.

Potential evidence from the victim's body would include:

- Reference DNA sample from the victim: this is used for identification and elimination purposes
- Genital swab(s): these may contain DNA transferred by the perpetrator (for example sperm cells or penile epithelial cells)
- Swabbing of the breast and external genital areas: DNA from sperm cells and DNA from epithelial cells transferred via the mouth or hands
- Swabbing other body surfaces that may have been touched or held, seeking to detect epithelial cells transferred through skin-to-skin contact from perpetrator to victim in the saliva

- Fingernail clippings or scrapings: may contain skin cells or blood of the perpetrator transferred during the attack.
- Pubic hair combings: transfer of foreign pubic hair.
- Victim's clothing:
 - Underwear: DNA from seminal fluid or epithelial cells
 - Outer clothing: DNA from possible body fluids and the presence of other trace evidence (e.g. fibres).
 - Personal belongings: may be relevant to assessment of identity or the criminal investigation.

Separate medical examination kits must be used for each individual. Preferably, the medical examinations will not occur concurrently, but will be sufficiently separated in time and space. Again, this is to eliminate the possibility of cross-contamination via a third party or shared examination facility. The medical examination kit will contain explicit examination instructions and a medical examination form which should be completed at each examination. This kit will address the provision of a reference sample in addition to the crime stains from the victim/suspect. It is important that, from the description of events provided by the victim, consideration is given to the possible deposition of DNA from those events. For example, if a victim says the attacker kissed him/her on the neck, then that provides a good reason to make an examination and swab of that area to attempt to locate the perpetrator's DNA.

The swabs taken from the victim or suspect should not be stored in transfer media (as is the case for microbiological analysis). This will destroy the DNA.

The large sheet of paper can be used to catch any trace evidence that may fall from the victim's body or clothing during the analysis. This item should be folded carefully and submitted with the remaining exhibits.

Reference Sample Kit

A DNA reference sampling kit contains at least the following items:

- Documented check-list, sampling instructions and guidance
- Sterile sampling system for taking buccal cells, blood or hairs
- Uniquely numbered and/or bar-coded seals, forms and sample containers
- Pairs of disposable gloves
- 1 x tamper evident bag/container (for return of sample)

Any individual taking a reference sample must wear the gloves provided throughout the whole sampling procedure. Once the sampling kit has been opened, he should ensure that the kit is complete by checking off each item against the check-list provided. After this the procedure should be followed according to the sampling instructions.

It is important to note that often the sampling instructions contain procedural requirements that must be followed under the DNA sampling legislation. For this reason, they must be followed with care and precision as any deviation from the procedure can lead to the reference sample not being admissible in court proceedings, as has happened in the past.

If at any time during the sampling process, the sample taken is dropped or comes into contact with any other surface the procedure should be stopped and the sampling kit disposed of. The samples should then be taken using a new DNA sampling kit.

Once the samples have been successfully taken, the wrappers and gloves should be collected and disposed of using designated receptacles.

As part of the collection procedure, the details of the donor and other necessary information should be noted on the form provided. The form and the samples should then be placed in the tamper evident container, stored appropriately and sent to the laboratory as per legal instructions.

This procedure should also be applied to obtain samples from persons associated with the offence, or the victim, or the crime scene. For example, in the case of sexual assault, it may be necessary to obtain reference samples from consensual sexual partners of the victim to assist in identifying any DNA that has originated from the perpetrator. Other examples include the owner of a car that has been stolen or the usual inhabitants of an area that has become a crime scene.

● ANTI-CONTAMINATION GUIDELINES

- Due to the sensitivity of current DNA techniques, extreme caution, including wearing a face mask, must be taken if the person undertaking the crime stain sampling has a medical condition that causes the shedding of body fluids or particles e.g. colds, coughs or influenza. Other conditions such as eczema or severe dandruff may require the wearing of additional barrier clothing.
- All containers used for transportation (e.g. cool boxes, crates, boxes) should be cleaned before and after use, or, if possible, not re-used.
- Scene of crime officers' work area should be cleaned regularly with wipes containing chlorohexadine.
- Wherever possible DNA-free, disposable sampling materials should be used.
- Disposable gloves must always be worn over cuffs and should be changed after handling individual items/objects. Barrier clothing should also be used as often as possible.
- For serious offences wear disposable face masks, overshoes and hooded suits.
- Handle items as little as possible, items should not be re-opened even for interview purposes. Use paper bags with transparent panels.
- Always handle one item at a time.
- It may be necessary to change gloves between the handling of different items.
- Where possible, take the container to the evidence and not the evidence to the container.
- Contact between victim and suspect samples should be avoided at all times.
- Ensure that any person attending a crime scene has no contact with a suspect or his/her clothing.
- Multiple suspects, the victim and their clothing must be kept apart at all times and should not be allowed to come into contact with the same objects (e.g. police car, interview room, custody suite).

- Each item should be packaged, sealed, and labelled as soon as it is taken.
- Never pack several items/objects together.
- Use bags of a suitable size or shape, do not force items into packaging that is too small, bags may tear or lids may be forced off.
- Seal all packaging securely; use adhesive tape on all edges and sign and date over seals.
- Never use staples or pins to seal packages.
- Never re-use packaging.
- If an item will not fit or packaging is used in error do not use it for a different item. It must be discarded.
- Never eat, drink or smoke when recovering evidential samples.

● CONDITIONS FOR STORING THE SAMPLES

- Dry samples should be kept at room temperature (cool if possible) and out of direct sunlight. Dry samples stored at ambient temperature should not deteriorate/ decompose/ degrade and will remain suitable for future DNA analysis. Breathable bags, cardboard packaging and brown paper bags will allow a sample to dry out whilst safely packed away and should be stored as above. Plastic or air-tight containers are not suitable for the storage of biological exhibits.
- If samples are air dried then this must take place in an area free from any contaminant, for example, in a sterile drying cabinet or laboratory fume cabinet. If this is not achievable and there is any risk of minor contamination then samples should not be air dried.
- If samples are frozen then they should be kept frozen and never be allowed to thaw and refreeze since this will cause the breakdown of DNA.
- Plastic bags can on rare occasions be used to transport very wet items but this should be on the instruction of the local forensic science laboratory.

● TRANSPORT TO THE LABORATORY

All samples containing biological materials should be placed into suitable secondary packaging for transport to the laboratory. Local transportation regulations should be adhered to. This can include the use of the international biohazard symbol. Samples should be transported to the (local forensic science) laboratory as per legal or local police force procedures and guidelines.

● CLEANING AND DECONTAMINATION GUIDELINES

Commercial thick bleach can be used for spillages of biologically hazardous materials. This should be left in contact with the contaminated area before rinsing and wiping dry. For general disinfection (e.g. work surfaces after handling biological specimens) a 1-in-10 dilution of commercial thick bleach should be used as above. It should be noted that dilutions of thick bleach do not remain effective for periods in excess of a few days. An alternative cleaning solution is Micro sol 3.

Once evidence has been collected and packaged at the scene it is then sent to the laboratory for analysis. When a laboratory receives a DNA sample, receipt needs to be confirmed and documented so that the sample can be continuously monitored. The standard operating procedure (SOP) for this should be an integral part of the facility's standard operating protocol. The SOP should address security issues to ensure that the chain of custody can be identified at all stages. Also, accreditation of a lab should be based on appropriate International Organization for Standardization (ISO) guidelines relevant to DNA profiling processes (see *Quality Assurance*). These guidelines focus heavily on traceability and chain of custody integrity issues.

● REVIEW OF THE EXHIBITS

Evidence collected from the crime scene is reviewed by the laboratory in discussion with the investigating officer to determine which evidence will successfully yield a DNA profile and which samples give the best probable investigative lead. Some analysis seeks to assist the investigation with the identity of the suspect, whilst other evidence helps to establish the elements of the crime and presentation of the evidence in court.

It is important for the objectives of the forensic analysis to be clear and for strong lines of communication to exist between the various parties involved. Effective communication between the investigator and forensic personnel is important throughout the investigation. This allows the priorities to be reviewed as the circumstances of the case unfold.

There should be an ongoing review of the forensic strategy supporting the case as more facts become known to the investigators. Science can then be used to establish unknown facts, answer questions or corroborate investigative hypotheses.

● OBTAINING A DNA PROFILE FROM THE EVIDENCE RECOVERED AT THE CRIME SCENE IN THE HANDBOOK SCENARIO

The examples below are specific to the scenario in this handbook and give an overview of some of the items and techniques that may be used to obtain a DNA profile. Many more are available and each case will use the most available and appropriate methods possible.

Medical Examination Kit:

The swabs collected from the body of the deceased female would be processed to try to obtain foreign DNA that may have originated from the perpetrator. This process involves screening the swab using biochemical tests that help identify the presence of biological material, such as semen. The cotton is removed from the swab tip and subjected to the five steps of DNA analysis (see *figure below*). In this scenario, semen has been detected on the vaginal swabs of the deceased female and a male DNA profile has been obtained. It is believed that this profile could have originated from the perpetrator.

It is important to keep in mind that foreign DNA may be present due to a consensual partner before the crime was committed. The investigation should take this into consideration and try and establish if this is a possibility. It is likely that other evidence will be required to corroborate with any foreign DNA found for a successful conviction, highlighting the fact that DNA is just one forensic tool in an investigation.

Underwear:

The underwear of the deceased female was examined for the presence of foreign DNA. This involved a similar regime of biochemical screening and DNA analysis as the medical examination kit. No foreign DNA or semen was located on these samples.

Swabbing of door knobs and other relevant surfaces:

State-of-the-art DNA techniques can be used to detect minute quantities of DNA recovered from touched objects and surfaces. There is a high possibility of mixtures of DNA profiles being recovered from these items and some of these may be of low evidentiary value. Interpretation of these results can also be difficult and can lead to the reporting of inconclusive results.

● DNA PROFILING INVOLVES FIVE STEPS

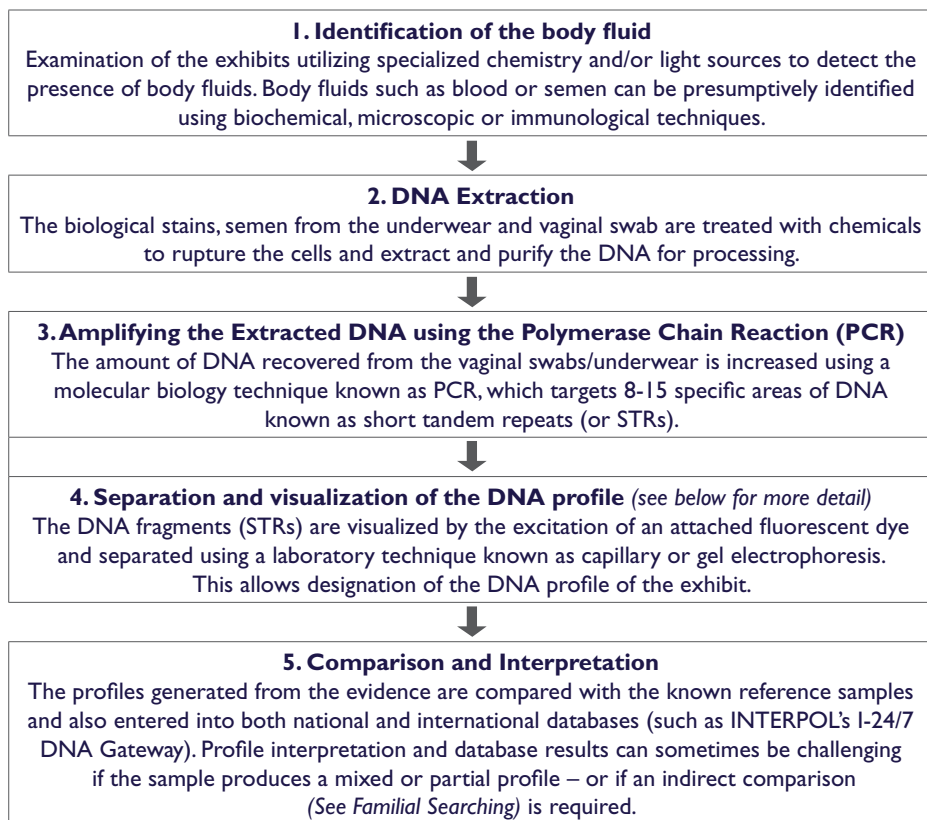


Figure 1: Flow chart of the five steps of DNA profiling

Detail of Step 4-Figure 1 - Separation and visualization of the DNA profile

Routine forensic DNA profiling targets markers on the DNA known as short tandem repeats (or STRs). STRs first emerged as potential forensic markers in the early 1990s and quickly demonstrated important advantages as a forensic technique. In particular, their small molecular size meant the tests were more sensitive, requiring as little as 0.2–0.5ng of DNA. This is 100 to 250 times more sensitive than the original DNA profiling techniques. This also meant that these loci had improved reliability when the DNA was highly degraded.

Analysis of STRs has advanced to the point where up to 16 individual STR markers are combined into a single test. This technique (known as multiplexing) increases the discriminating power of the DNA analysis without compromising the overall sensitivity of the test, or its suitability in the forensic context.

YEAR OF RELEASE	NAME	NO. OF LOCI
1997	AmpFISTR Profiler Plus®	10
1998	AmpFISTR COfiler®	7
1999	AmpFISTR SGM Plus®	11
2001	AmpFISTR Identifiler®	16
2001	PowerPlex® 16	16

Table 3: STR multiplexes commonly used in forensic DNA profiling

Note that we have three types of DNA analysis:

1. Set of markers used for national DNA database that can provide identification of an individual through direct comparison
2. Markers such as Y-STRs and mtDNA that can exclude numerous people but may not be sufficient for identification/individualisation in its own right
3. Other markers that may assist investigators by providing an indication of aspects such as geographical origin, physical characteristics etc.

INTERPRETATION OF THE DNA PROFILE

As demonstrated in the previous flow chart, DNA profiles can be compared in a DNA database, however the data in a DNA profile from a laboratory is presented in a very different format from the way in which it is entered into a database.

An example of a DNA profile obtained from one of the routine tests (the Identifiler® system) is presented below:

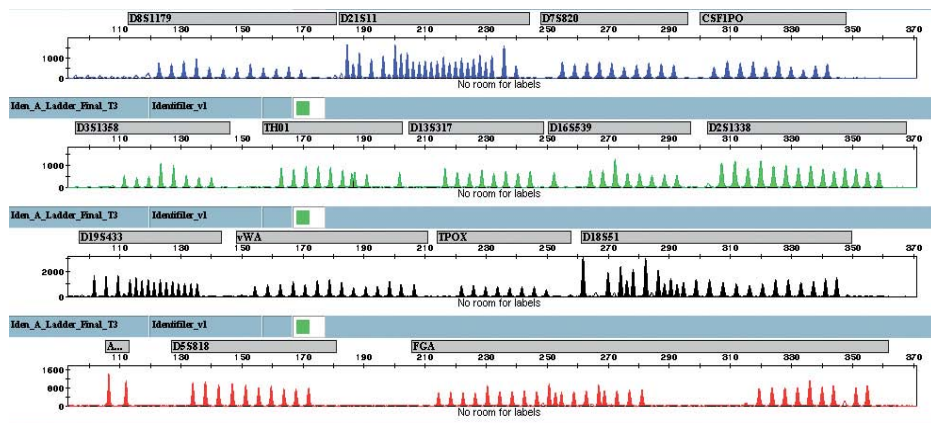


Figure 2: The 16 loci amplified using the AmpFISTR® Identifiler® Multiplex System

Reproduced from AmpFISTR® Identifiler® PCR Amplification Kit Product Bulletin, Applied Biosystems, Foster City, Ca.

It is imperative that the investigating officers understand the basic elements of a DNA report, the terminology used and the overall significance of the results and its impact on their case.

● BASIC ELEMENTS OF A DNA REPORT

Different laboratories vary the format of their DNA reports, however quality control standards dictate that the laboratory report must include statements that address the following basic elements:

- Description of all items received and their packaging, labelling and personal transfer of custody of the exhibits from the investigator to the laboratory, and summary of the established chain of custody
- Description of evidence examined
- Methodology used for examination
 - Scientific screening of items and the testing of Short Tandem Repeat loci (STRs) and an explanation of Polymerase Chain Reaction (PCR).
- DNA Results
 - The STR loci examined and the alleles detected are normally listed as a series of numbers representing the different forms of DNA (alleles) detected. The profiles themselves may or may not be reported in the laboratory report but the outcomes and conclusions from the testing will always be reported.
 - If the quality is sufficient, the profiles will be forwarded to the DNA Database. This will often not be possible when mixed stains or very low amounts of stains are detected. These samples can often be used for a direct comparison at a later stage when a suspect is found.
- Interpretation of results inconclusive
 - An inconclusive - DNA report in which the suspect is neither excluded nor included can occur due to insufficient DNA being present in the exhibits or the poor quality of the evidence. Inconclusive results also can occur if the evidentiary material contains a mixture of DNA from several individuals, for example a rape case involving multiple assailants, which prohibits interpretation.
 - No DNA or Insufficient DNA - The absence of DNA from the evidence may be because there is no DNA deposited (such as the use of a condom during a rape), insufficient DNA present in the exhibit, the DNA is degraded, or due to the presence of factors that inhibit the PCR amplification and subsequent analysis of the DNA. A negative result is not equivalent to an exclusion result, as it only means that DNA was not detected in the exhibit tested.
- Statement on the Deposition of Evidence
 - The evidence is packaged and returned to the submitting agency or it may have been consumed during the analysis.

THE MATCH REPORT

To get to step 5 of figure 1- Comparison and Interpretation, the profile above needs translating into an alphanumeric code. This code states the number of repeats present at each locus and it is this data that is entered into the database, as shown below: (please note this is not linked to the above image of a DNA profile and is a fictitious profile).

Reference: FP/01/09/cs															
VWA		TH01		D21S11		FGA		D8S1179		D3S1358		D18S51		amelogenin	
16	20	9	93	30	31,2	19	22	14	15	16	17	13	14	X	X
TPOX		CSF1P0		D13S317		D7S820		D5S818		D16S539		D2S1338		D19S433	
		12	12							11	10	23	23	13	15,2
Penta A		Penta E		FES		F13A1		F13B		SE33		CD4		GABA	

Figure 3: DNA Profile for entry in a DNA Database

Normally, the database will then search this profile entered against all profiles already present and will store the profile for future searches, unless there are other specific requirements.

● WHAT DO THE RESULTS MEAN?

1. Exclusion (Non-match)

The DNA profile from the known individual (reference sample from a victim, otherwise known as an elimination sample or suspect) does not match the DNA profile generated from the crime scene evidence.

2. Inclusion (Match)

The DNA profile from the known individuals (reference samples from victim or suspect) matches the DNA profile obtained from the crime scene evidence. The two profiles are consistent with originating from the same source.

The significance or strength of the match is indicated by a statistical statement termed the random match probability (RMP). For example a RMP of “1 in 6 billion in the Caucasian population” expresses the probability or chance of finding the same DNA profile in a random unrelated individual in the population. The larger (smaller) the number in the frequency estimate, the rarer the profile and therefore the more significant the results. The RMP does not indicate the probability of the suspect being guilty and great care should be taken not to convey this impression.

The following match(es) can be identified on the database:

- A new crime scene profile with the profile of a person already on the database
- A profile of a new person with the stored profile of a crime scene
- A new crime scene profile with the stored profile of a crime scene
- A profile of a new person with the same stored profile on the database, for example in the instance of this profile having been previously submitted under the same or different name.

If an exact match cannot be obtained, the possibility of identifying relatives still exists (see *Familial Search*).

A match between a crime scene sample and a reference sample on the DNA Database means that the DNA profile from the evidence is identical to the DNA profile of a person. This is an indication, not proof, that the evidence originates from that person. For example the person may have been there but not at the time of the incident but the DNA will still be present at the scene. It is the task of the police to gather all the supporting evidence for prosecution purposes.



CONCLUSION

A final conclusion in an understandable, clear, short text is necessary. The investigator needs concise feedback so as to not misinterpret the final conclusion.

CONCLUSION OF SCENARIO

In this particular scenario, the types of biological evidence that may be obtained from the scene can be listed in order of highest potential evidentiary value:

1. Rape kit:

- Vaginal swab
- Swabbing of the breast and genital area
- Swabbing of other body areas
- Fingernail clippings
- Pubic hair combings

2. Victim's clothing

3. Swabbing of door knobs

This order is based on the probability of finding DNA from the suspect present in sufficient quality and quantity to obtain a DNA profile. In this case, it was possible to obtain a full DNA profile from the vaginal swab. The suspected perpetrator's DNA profile was searched on the Austrian National DNA Database and did not produce a match.

Considering the international relevance, and also as part of the standard protocol in Austria for this type of offence, the profile was searched online on INTERPOL's autonomous global DNA Database. This search resulted in a potential match with a profile submitted two years earlier by South Africa for a known offender and matched as well with a crime scene DNA profile submitted by Croatia after a sexual assault (see figure 4).

The offender, identified as Russian citizen John EXAMPLE, had been convicted of rape in South Africa four years earlier. Through bilateral communication with South Africa, the identity of John EXAMPLE is made known to Austria. Aided with a possible identity of the Austrian airport murderer, police enquiries reveal that a Mr EXAMPLE was on a passenger list for a flight from Vienna to Beijing, China the day the murder happened at the airport. A physical description of Mr EXAMPLE also matched that of a man seen on CCTV footage in the vicinity of the crime scene. Austria is therefore seeking the arrest of Mr EXAMPLE worldwide. An international arrest warrant was issued by the High Court of Vienna.

Based on the DNA profile and corroborating information from the National Central Bureau (NCB) and the international arrest warrant, Austria requests INTERPOL to issue a red notice (see full notice at Appendix 2) to help locate and extradite this wanted individual.

An INTERPOL red notice allows a warrant for arrest to be circulated worldwide with a request that the wanted person be arrested with a view to extradition. (See appendix 2).

Consequently, two months later, police in Shanghai, China arrest a foreign individual for drunken disorder and assault. At the police station the fingerprints and nominal information are taken and immediately found to correspond to the data on the INTERPOL red notice. Instead of being released by the Chinese authorities, due to the nature of the crime, Mr EXAMPLE is detained and his DNA profile later found to also match that on the red notice. Chinese and Austrian officials are to co-ordinate the extradition of Mr EXAMPLE to Austria.

Figure 4: Potential-Match Report

Potential-Match Report

DNA Profile Searched:

Country: AUSTRIA										Index: Crime Scene									
NCB Reference: 124/147/M-PU212001										Offence: Murder									
Country Agency: Bundeskriminalamt Austria										Agency Reference: EP/ALW/FS/0235									
National DNA Profile ID Number: 85C01234588AB										Accreditation: Yes									
VWA		TH01		D21S11		FGA		D8S1179		D3S1358		D18S51		Amelogenin					
3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
TPOX		CSF1PO		D13S317		D7S820		D5S818		D16S539		D2S1338		D19S433					
PENTA D		PENTA E		FES		F13A1		F13B		SE33		CD4		GABA					

The DNA profiles contained in this report have been searched in Interpol's DNA database and a potential-match has been detected based on the profile information provided by the contributing Member States. Member States contributing to this potential-match have been notified. Additional information concerning the origin of matched profiles may be requested from the contributing country's. This profile has now been added to Interpol's DNA database and will continue to be searched against all new in-coming profiles until deleted by, or on behalf of, the original contributor.

Les profils d'ADN faisant l'objet du présent rapport ont été comparés à ceux de la base de données génétiques d'Interpol, et une concordance possible a été obtenue, d'après les éléments communiqués par les Etats membres ayant transmis les profils. Les Etats membres intéressés ont été informés de cette possible concordance. Pour tout renseignement complémentaire relatif à l'origine des profils concernés, prière de s'adresser aux pays qui les ont transmis. Ce profil a été ajouté à la base de données génétiques d'Interpol et continuera à être comparé à tous les nouveaux profils enregistrés, jusqu'à sa destruction par le pays qui l'a communiqué, ou à sa demande.

Tras efectuar la búsqueda pertinente en la base de datos de ADN de Interpol se ha encontrado una posible coincidencia, basada en la información facilitada por los Estados miembros, entre los perfiles de ADN que figuran en este informe y los de la base de datos. Los Estados miembros que han contribuido a esta posible coincidencia han sido informados al respecto. Podrá solicitarse de los países que han facilitado los datos información adicional relativa al origen de los perfiles posiblemente coincidentes. Este nuevo perfil ha sido incluido en la base de datos de ADN de Interpol y, hasta que sea eliminado por quien lo haya facilitado o por alguien en su nombre, seguirá cotejándose con todos los perfiles que se vayan incorporando a la base.

وقد كانت مطابقة ممكنة استنادا إلى معلومات زودت بها الدول الأعضاء لمساهمة، جرت مقارنة سمات الدنا المضمنة في هذا التقرير بمحتويات قاعدة الإنتربول الخاصة ببيانات الدنا هذه للسمات التي في قاعدة الإنتربول الخاصة ببيانات الدنا وقد يطلب من البلدان المساهمة بمعلومات إضافية عن منشأ السمات المطابقة الممكنة. وجرى إشعار هذه الدول بالمطابقة الممكنة ويستحسن مزامنتها بجميع السمات الجديدة الواردة حتى يصل إلى كشفها أو حذفها بواسطة المساهم الأصلي أو بشأته عنه وضامت.

DNA Profile(s) Matched:

Country: SOUTH AFRICA										Index: Reference Sample							
NCB Reference: ILM-56890/2006										Offence: Assault							
Country Agency: South African Police Service										Agency Reference: SAPS/087654/2DRG							
National DNA Profile ID Number: K-3456789										Accreditation: Yes							
VWA		TH01		D21S11		FGA		D8S1179		D3S1358		D18S51		Amelogenin			
3	4	5	6	7	8	9	10	11	12	13	14	15	16	X	Y		
TPOX		CSF1PO		D13S317		D7S820		D5S818		D16S539		D2S1338		D19S433			
										16	17.1	18	19	20	21		
PENTA D		PENTA E		FES		F13A1		F13B		SE33		CD4		GABA			
Mismatch: No										Derivation: No							

Country: CROATIA	Index: Crime Scene
NCB Reference: MHP/2323239/AY	Offence: Sexual assault
Country Agency: NCB Zagreb	Agency Reference: IP/2006/456789/OP
National DNA Profile ID Number: 147258369	Accreditation: Yes
INFORMATION LIMITED BY THE OWNER OF THE DNA PROFILE	
Mismatch: No	Derivation: No

WARNING: TO VALIDATE THIS MATCH LABORATORY DATA CONCERNING ALL PROFILES CONTRIBUTING TO A MATCH SHOULD BE COMPARED AND INTERPRETED IN ACCORDANCE WITH NATIONAL PROCEDURES BEFORE INITIATING ANY FURTHER JUDICIAL ACTION.

AVERTISSEMENT : POUR VALIDER CETTE CONCORDANCE, AVANT D'ENGAGER TOUTE PROCEDURE JUDICIAIRE, LES DONNEES DE LABORATOIRE RELATIVES AUX DIFFERENTS PROFILS DEVRONT ETRE COMPAREES ET INTERPRETEES CONFORMEMENT AUX PROCEDURES NATIONALES.

ADVERTENCIA: PARA VALIDAR ESTA COINCIDENCIA, ANTES DE INICIAR UNA ACCIÓN JUDICIAL LOS DATOS DE LABORATORIO SOBRE LOS PERFILES COINCIDENTES DEBERÁN SER COMPARADOS E INTERPRETADOS DE CONFORMIDAD CON LOS PROCEDIMIENTOS NACIONALES.

التحقيقات الوطنية، أن يشار إلى مقارنة وتفسير البيانات المخبرية المتعلقة بالسمات التي أدت إلى المطابقة يجب قبل العائشة بأي إجراء قضائي للمصادقة على هذه المطابقة بتحليل بولك ولفا

PART I: CASE SCENARIO

DNA INVESTIGATIVE CONSIDERATIONS

A clear structure for media relations should be in place, so that at any given time rules and guidelines are available for dealing with the media, between organizations and within an organization.

Any explanation on the use, background or inclusion of DNA profiling in an investigation would normally be part of a wider media strategy implemented by the appropriate media relations unit.

The provision of information to the media should be done in co-operation, and after consultation, with the appropriate press office or dedicated press officer on the case. This will ensure that people providing the information are properly prepared, and the press office can ensure that the widest possible media coverage is achieved.

A general background document on the use of DNA in investigations should be prepared and regularly updated so that it is available for distribution at any time (see *Appendix 5*). Examples of the kind of details which could be included in such a factsheet are: an explanation of the process for obtaining DNA samples, how matching is done, what types of cases DNA profiling is suitable for, and also any data protection issues about DNA samples taken during an investigation and what happens to those samples afterwards.

Anyone giving information about DNA should possess the relevant expertise in this area, and if not closely linked to a particular investigation, should consult with investigating officers to ensure that they do not divulge any potentially sensitive information which could jeopardize the case.

The following remarks and issues should be part of the background, as they can be extremely helpful as additional information.

- DNA profiling is recognised as a very effective investigative tool of our time.
- DNA can be extremely cost effective.
- DNA can both exonerate the innocent and identify perpetrators.

Similarly, any individuals giving interviews to the media should ensure that they are fully prepared with any background information which may be required and that they have received advice in dealing with the media if they have not done so before.

Quality principles need to be applied in every step of the law enforcement chain, so that from the crime scene, through the process of analysis in the laboratory, to the courtroom, the validity, reliability, and reproducibility of the DNA profile is ensured as much as possible. DNA profiles are loaded onto national and even international DNA Databases to maximise the efficiency of the investigations, some countries even share their entire national DNA Databases. In order to have confidence in the results provided through database searches, it is essential that an uncontaminated DNA profile obtained from a person and from the crime scene appears on a DNA Database.

● IMPACT ON THE QUALITY

The following matter can impact on the quality of the DNA profile:

Contamination

When identifying, collecting, preserving and analysing DNA evidence, particular care should be taken to avoid contamination. Even trace samples of DNA can be used as evidence and DNA contamination can be genetic or non-genetic, so precautionary steps must be taken to avoid this. Non-genetic contamination may result in sample breakdown or inhibition of the amplification of DNA, which may in turn lead to an inconclusive DNA result. Genetic contamination occurs when DNA evidence comes into contact with DNA from other sources, for example:

- Persons who have had access to the samples collected (operator contamination);
- Other samples (cross-contamination);
- Equipment and materials used to collect and analyse the samples (laboratory contamination);
- The environment generally (background contamination).

Contamination may occur, for example, when a person sneezes or coughs over evidence that may contain DNA. If the DNA sample is then submitted for testing, the PCR process will copy whatever DNA is present in the crime scene sample. As PCR cannot distinguish between the DNA from the original source and the DNA from the source of contamination, the result may be interpreted incorrectly.

There are many ways to prevent contamination (see *DNA Sampling and Evidence Collection*) that need to be considered, so that a profile can be as accurate as possible. The risk of contamination occurring in laboratories is reduced by adhering to procedures when handling samples. Procedures that can be put in place to reduce contamination include making the analysis automatic, using the necessary controls and checks, wearing appropriate protective clothing, having separate and designated work areas for post- and pre-amplification processes, controlling air flow in laboratories and even restricting the movement of staff and equipment to designated work areas.

Measures are also required to allow such contamination to be detected if it cannot be prevented. It is advisable for law enforcement officers and forensic personnel to provide reference/elimination samples, so that they can be compared against the evidence at the scene. If the DNA evidence collected does not match the elimination samples, it means that the DNA may have been left at the crime scene by the person who committed the crime, and not by professionals involved in its collection or analysis. This could therefore imply that the profile collected was from the person who committed the crime and would need investigating.

Chain of custody

The chain of custody refers to the process of documenting how evidence is collected, analysed, stored and protected from initial collection at the crime scene all the way to introduction before a court of law. The chain of custody verifies that the evidence was handled carefully and has not been damaged, tampered with or changed in any way.

All procedures regarding scene preservation, control and recording should be fully documented and available to all police and other forensic personnel who have legitimate business at scenes of crime.

Data integrity

Normally a DNA profile is loaded on to the DNA Database as part of a record which might contain information such as the unique bar code reference number, information about the crime and the laboratory that analysed the sample, the person's name, and identification number, the gender and the sample type.

The possibility of errors can undermine the usefulness of the DNA Database and the reliability of DNA evidence. Errors in data handling occur when samples are mislabelled during processing and result in incorrect information being submitted to the DNA Database so that a DNA profile is incorrectly attributed to a person's record, giving the wrong DNA reference for that person. This can lead to false matches where an innocent person is wrongly accused of a crime (false positives) or even where a criminal is excluded from suspicion (false negatives). The best ways to avoid these problems is by only handling one item at a time and having a second person checking the labelling.

Many laboratories have introduced a modular approach in which robots have replaced manual involvement in a number of the key stages. The use of robots minimizes human intervention and improves the processing time. These robots carry out the logging/batching of samples, extraction of samples, the amplification of DNA and preparation of electrophoresis. Manual intervention is only required to transfer the plates between the processes and workstations or in/out of storage. This implies that the samples are no longer handled in individual tubes but rather as batches on 96-well plates. Each sample and plate has a unique identification number through which its progress can be tracked via the sample management system. Expert systems are now being used

to interpret the more complex results generated from crime scene samples, such as mixtures. However scientists are still required to review and validate the interpretation before it can be officially accepted. The latest advances in these kinds of software systems have made them more sophisticated in terms of the rules they apply to the result, so that now only the occasional result is referred to the scientist for review.

● MEASURES TO ENSURE CONFIDENCE

Laboratories have to prove that they can consistently produce DNA profiles that are reliable. The forensic laboratories and the DNA Database in any country should be accredited or be in compliance with standards such as the ISO Guide, ISO 17025¹ in order to upload DNA profiles to national DNA Databases. Other standards can be found on the CODIS website, the FBI Director's Quality Assurance Standards for Forensic & Database Laboratories² and the European Network of Forensic Science Institutes (ENFSI) homepage³. These standards cover different factors that affect quality including training and proficiency of personnel, the physical environment in which the analysis is completed, the equipment and methods used, and the handling of items being analysed.

Quality Assurance programmes such as European Network of Forensic Science Institutes (ENFSI), International Laboratory Accreditation Co-operation (ILAC, United Kingdom), Australia's National Association of Testing Authorities DNA Guidelines (NATA), R42-01 (South Africa), and National Standards issued by the Director of the FBI (United States) provide DNA guidelines directed towards ISO 17025.

Accreditation can be achieved after an assessment has been conducted by an impartial agency which checks that a laboratory is in compliance with the necessary performance standards. National accreditation bodies which conduct quality assurance audits exist in many countries. Examples are the United Kingdom Accreditation Service (UKAS), Raad voor Accreditatie (the Dutch Accreditation Council), the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB), Forensic Quality Services (FQS) and the Swedish Board for Accreditation and Conformity Assessment (SWEDAC), Australia's National Association of Testing Authorities (NATA), the Accreditation System for test laboratories and inspection bodies (BELTEST, Belgium), and the South African National Accreditation System (SANAS).

Laboratories have to prove that they are continuing to meet the required standards through a programme of internal and external quality audits. Furthermore, the courts must have confidence in the DNA results obtained by the laboratory, therefore laboratories must ensure that these DNA results are accepted by adhering to their quality programme.

Training is essential to ensure that the highest quality of results is achieved from all stages of the investigation. With several different personnel often being involved in the investigation it is necessary for them to complete different kinds of training specific to their individual roles. However, there will be some overlap in their knowledge, as the same basic concepts must be upheld throughout all stages including continuity, integrity and reliability.

The following information is aimed at providing all participating member countries, including countries still developing forensic DNA profiling capabilities, with a framework upon which international standard procedures can be built. These procedures will naturally differ between jurisdictions depending on legal, social and cultural aspects but they will all have a common adherence to the same high standards required for the various phases of the DNA profiling process.

Training programmes are very important to all police force personnel; it is a continuous process and it should never stop. The value of the results obtained from forensic investigations depends on the knowledge, education, skills, and experience of all police officers involved.

● FIRST ATTENDING OFFICERS AT SCENE OF CRIME

For police personnel arriving first at the scene, their Standard Operating Procedures (SOP) should be the reference for any action they decide to take. If the first responders are crime scene examiners then they should follow their scene examination process according to their SOP.

Likely first responders to a scene should be given a special DNA awareness training course, which could be provided by a specialist such as a crime scene investigator or specialist from the DNA section of a forensic science laboratory, or both. While there are international standards that define forensic agency requirements for crime scene procedures, general duty police officers would normally not be required or expected to meet these standards. There is also the possibility that first responders may not be police personnel, but paramedics or other medical staff. Where possible, some best practice guidelines should be provided to these agencies so that they are aware of DNA and its use in investigations. However, preservation of DNA will always come second to preservation of life.

Training for first responding officers should include information on how best to deal with a scene so that DNA evidence is not damaged, destroyed or contaminated. The types of evidence that can provide DNA, how to handle them, and advice on what do

to ensure the best possible results should also be included. All of this training should be provided alongside the principles that DNA is not the only type of evidence that may be available at a scene, and the most important priority is the responsibility to preserve life. This type of training would help enforce essential guidelines to ensure that as much evidence was obtained from a scene as possible, in the best possible condition.

● CRIME SCENE INVESTIGATORS

The activity within the crime scene should be controlled by a suitably trained Crime Scene Manager and his team. Training for crime scene examiners can be obtained in numerous ways, one possibility being to attend a course given by some university institutes offering courses in Forensic Science, or similar, which have a focus on crime scene evidence collection. Another option is to attend a course specifically organized for police officers wishing to specialize in crime scene investigation. The most common method of educating police personnel in this field will be through police-organized training courses that focus on all aspects of evidence collection. It should be assumed that all actions conducted will be subject to scrutiny in court, for example the collection and preparation of samples possibly containing DNA evidence, so they should be collected by appropriately trained individuals wherever possible. All procedures should be fully documented and available to all police and other forensic personnel who have legitimate business at scenes of crime. There are international standard formats for documenting these procedures under the ISO Guidelines, and while it is not essential to use them, they serve as a ready and uniform platform for this purpose and are recommended as a good starting point.

The crime scene DNA sample collection procedures established within a country/ jurisdiction must ideally be identical to, or at the very least be compatible with the documented procedures within the forensic laboratory, and vice-versa. This will ensure that as far as humanly possible, the training of the crime scene personnel matches that of the laboratory staff who will analyse the DNA sample.

Quality at the scene of crime is very important and there are many guidelines for quality controls. However, ideally, the guidelines set by the ISO would be the most preferable option to allow the same standard to be met in all jurisdictions.

In summary, we can say that the first officer arriving at the scene of crime should receive special training and awareness regarding DNA samples. Crime scene investigators should follow more advanced training courses regarding DNA samples. Training programmes should be competency-based, with a formal assessment resulting in a formal authorization, thus allowing the individual to perform the work of which he has successfully demonstrated a command.

Summary

- Training needs to distinguish between the responsibilities of the First Attending Officers and Crime Scene Examiner Specialists, and both require documented programmes with clearly identified learning outcomes.
- This training must link with the procedures/processes of the servicing DNA laboratory.
- The training for the first responding officer must also include the normal first response elements, not just the actions relating to DNA preservation.
- The training for the crime scene examiner must include all actions required for a comprehensive and high-quality scene examination, and not be limited to DNA collection only.
- This training must include understanding of DNA profiling capabilities and limitations.
- Training programmes should be competency-based, with a formal assessment resulting in a formal authorization, thus allowing the individual to perform the work of which he has successfully demonstrated a command.
- This training should be included in some form of accreditation programme or meet equivalent standards set for general-duties police scene attendance.

● LABORATORY ANALYSIS

The laboratory must have fully documented training procedures and methods which prescribe Quality Assurance (QA) requirements that are to be understood and met in the analysis programme generally, and in the practice of DNA profiling particularly. Training of laboratory personnel should be assessed formally and staff should be authorized to perform the various aspects of the DNA profiling process for which they have been trained. It is up to each country/jurisdiction to formulate the actual content of these programmes and the guidelines to apply thereto.

● INTERNATIONAL STANDARDS

There are also well-established international standards for the conduct of forensic DNA profiling. These relate to the physical requirement of separate critical steps of the process. Laboratory staff must be made aware of these standards in their training to ensure a uniformly high quality of DNA profiling reliability.

The sections of forensic accreditation programmes referring to the procedures for dealing with other types of evidence should also be adhered to. These points should become essential parts of the training process. Some of these points relate to the qualifications of staff undertaking certain functions, the ongoing training and development of laboratory staff, and the QA critical requirements for proficiency testing, both internal and external. The intimate connection between training requirements and QA requirements is evident here; adherence to these accreditation standards should be an integral part of the training programme for forensic DNA laboratory personnel.

● IN-LABORATORY TRAINING

Another aspect of in-laboratory training is appropriate awareness of relevant DNA legislation. This varies enormously from country to country, and in some countries such as Australia and the United States, it also varies within the country between the component States. Some elements of the legislation are important to the DNA analyst, as several issues concerning sample legality, privacy, and status for testing, impinge on the validity and the ability to report on the DNA profiling results.

● EXPERT EVIDENCE

The provision of expert evidence in the area of DNA profiling has attracted extensive attention world-wide. The debate has covered all possible areas of the DNA analysis process, the scientific interpretation of results and the reporting of these results in terms of likelihood, probabilities, and population genetics. The DNA analyst must be trained to express scientific terms and concepts in understandable but accurate language.

Training in this area must ensure that the individual has awareness of the simple approaches to reporting results, documented processes for statistical reporting, and installation of skills to determine the direction of questioning which, if done incorrectly, could cause confusion or, worse, distortion of the DNA evidence.

Civil liberty and privacy issues continue to emerge and awareness training and understanding of these issues is a critical part of the DNA evidence-giving process.

An important issue to address and ensure that the most up-to-date information is available, concerns the use of the non-coding areas of DNA.

Summary

- Training must be based on documented programmes with clearly identified learning outcomes.
- Training programmes should be written in accordance with international accreditation guideline formats.
- Training programmes should be competency-based, with a formal assessment resulting in a formal authorization, thus allowing the individual to perform the work of which he has successfully demonstrated a command.
- These programmes should be delivered on a command basis allowing for differences in learning rates, but with upper time limits to ensure efficient and cost-effective training schedules.
- Alongside all relevant technical aspects of the methods employed, the programmes should also cover QA, proficiency testing and audits.
- Training on statistical approaches to DNA evidence is essential.
- Training must also include comprehensive understanding of the relevant legislation.
- Training programmes must include expert evidence training, preferably utilizing local Public Prosecutor/Defender office personnel, and subjects such as video techniques.
- Training programmes should also contain awareness information regarding privacy and civil liberty issues.
- These programmes are to be delivered within forensic laboratory training systems, via associated tertiary education institutes, and formalized programmes with legal offices responsible for prosecution/defence and court services.



LEGAL COURTS AND THE JUDICIARY

Perhaps the greatest requirement under this heading is to ensure that all parties have a clear understanding of what are DNA and the forensic DNA profiling process we employ to provide evidence to Courts. The fact that forensic DNA profiling currently utilizes non-coding areas of the DNA molecule is fundamental to understanding the significant variability that can be demonstrated between individuals. It is therefore essential for any jurisdiction to dedicate significant effort to educating/training court officers in regard to the process, the capabilities and the limitations of forensic DNA analysis. There are many issues, situations and scenarios that must be appreciated by these people in order to realize the full value of DNA evidence in the various tribunals in which it is introduced. Trace DNA, degraded sample, mixtures of more than one person's DNA, and contamination from the environment in which the sample is left or from interfering agents that may be present, all impinge on the DNA results obtainable. Awareness and understanding of these, perhaps as limitations to the process, are important training issues.

● KEY EDUCATION REQUIREMENT

Another key education requirement is a clear understanding of the extensive QA systems we employ for forensic casework, including DNA and why and how this is used to ensure, as far as humanly possible, that no errors escape detection in the high-quality, robust procedures established under accreditation programmes. We must continually draw attention to the manuals we produce describing training methods, proficiency testing, quality controls, etc., that are integrated into the forensic analysis system.

An understanding also of the various statistical approaches to reporting DNA results and why such techniques are employed is vital in the court context. While it cannot be expected that all judicial officers can/will have a comprehensive understanding of the statistics, we must ensure sufficient awareness so that the inherent value of DNA evidence is not compromised.

Summary

- Training information for this group is educational information.
- Information must start with a clear understanding of what DNA actually is and how forensic DNA profiling systems work (non-coding areas).
- Information regarding capabilities, limitations and the extensive analytical controls in place, is critical.
- An understanding of the use of statistics and the various general approaches to DNA statistics is essential.
- Develop a clear understanding that DNA evidence is extremely powerful definitive evidence, both inclusive and exclusive.
- This information/understanding to be provided via: seminars, laboratory open days, articles in legal publications, handbooks, pamphlets, newspaper articles and testimony.
- Feedback on understanding should be gained from question and answer sessions, programme critiques, and questionnaires.

● PUBLIC, COMMUNITY AND GENERAL AWARENESS

Community Education

Last but by no means least, we need to concern ourselves with community education and training so that general public awareness is as high as possible. The importance of this part of the “training package” is that public confidence is reflected in government policy through legislation and budget. Privacy debates and lingering civil liberty concerns can erode public confidence, and replacement of misinformation with factual DNA information is essential.

The community must be satisfied that the integrity of DNA samples from the crime scene, through the laboratory process and the results of analysis of those samples presented in the courts, is at the highest level.

Quality Assurance

They must be fully apprised of the extensive QA systems in place to monitor each and every step of the analytical DNA process. Awareness of the extensive checks and balances inherent in legislation covering DNA sampling and analysis, and of the extensive efforts made in the presentation of DNA evidence in courts to provide the best assessment of the value of that evidence in scientific and statistical terms, is essential.

Public understanding of the capabilities and limitations of forensic DNA typing can be dealt with through information that details the robustness and reliability of the techniques.

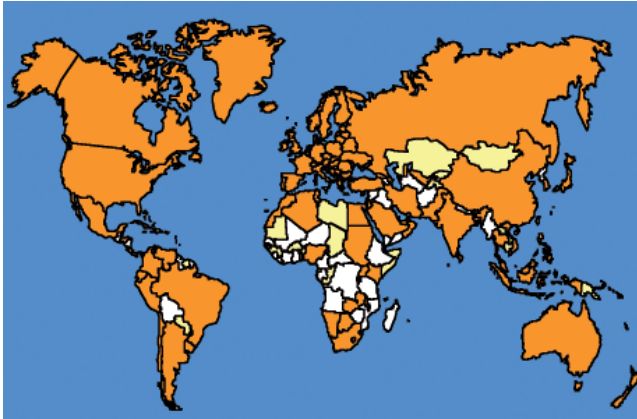
Information should also cover privacy concerns, stating that genetic data are only used for the purpose for which they were collected and that no further analyses will be done.

PART II: AN OVERVIEW

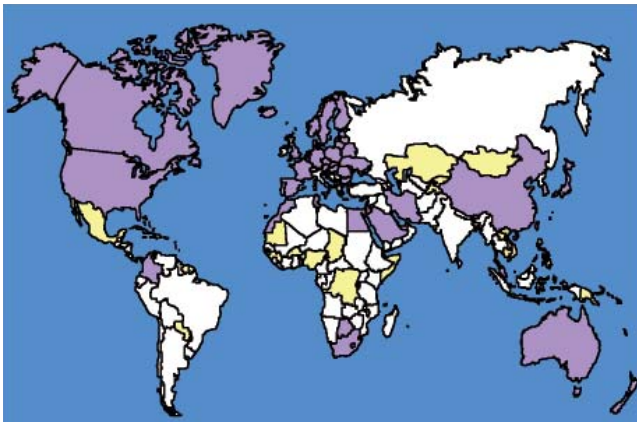
DNA DATABASES

STATUS ON EXISTING NATIONAL DNA DATABASES

In order to obtain a global overview of the use of DNA profiling in criminal investigations among its 188 member countries, INTERPOL has conducted three surveys since 1999. The results of the latest survey, completed in 2008, are based on replies from 172 member countries. To date, INTERPOL is aware of 120 countries that are known to use DNA profiling in their police investigations and 54 countries that are known to have a national DNA Database (See Figures 5A and 5B below).



*Figure 5A: World map of countries performing DNA profiling in orange
Countries which do not perform DNA profiling are shown in white.
Countries whose profiling status is not known are shown in yellow.*



*Figure 5B: World map of countries with a national DNA Database in purple
Countries which do not have a national DNA Database are shown in white
Countries whose databasing status is not known are shown in yellow.*

With the increasing use of DNA profiling by countries (there has been a 126% increase since 1999), more and more countries are relying upon national databases to store, manage and compare their DNA profiles. When the first DNA Databases were developed in the mid-1990s, their potential value for police investigations was not fully appreciated. The consequent advantages for police investigations in terms of solving crime continue to encourage the development of national DNA Databases across the globe. This trend can be seen in Figure 6, which illustrates how the number of member countries with a national DNA Database increased by 38 (238%) between 1999 and 2008.

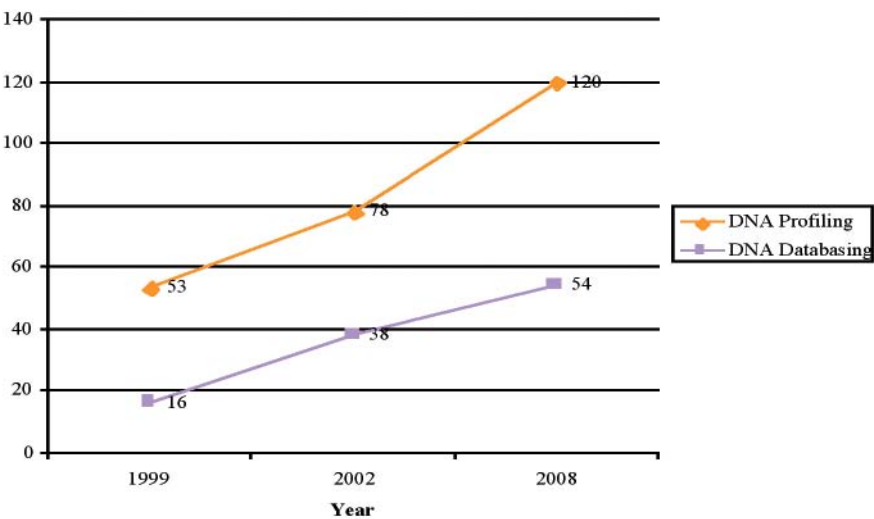


Figure 6: Global increase in DNA profiling and databasing over the period surveyed, from 1999 to 2008.

Initially, many countries restricted the upload of DNA profiles into their national databases on the basis of the type of crime scene from which biological evidence was taken (e.g. violent crime). Criteria were also applied to individuals' profiles to be entered into the database, for example, convicted offenders often had to have been served a minimum prison sentence.

Many countries have expanded their criteria to allow for the inclusion of more crime types and person profiles, which in some countries may include any recordable offence. Likewise, in many countries the criteria for entering a person's profile is not merely restricted to convicted offenders but may also include suspects. Countries also use national DNA Databases to match other profile categories such as unidentified bodies and missing persons. A global comparison of the main profiling categories shows that, according to the INTERPOL DNA survey replies, the one category used by all countries for DNA profiling is 'Crime Scene', and the highest number of DNA profiles is produced for the known offender category.

The more crime types and suspects there are in a national DNA Database, the higher a country's crime detection rate will be. National databases often have match rates for linking a crime scene profile with a previously stored person (between 20-50%). It is therefore clear that DNA Databases can be used to solve high-volume crimes such as burglary or car thefts which are traditionally very difficult crimes to solve by other means. DNA Database research has also shown that perpetrators often do not limit themselves to one crime type. For example, it has been known for DNA profiles from unsolved murders to be matched in a database containing offenders' profiles for much more minor crimes, such as theft. The chance of finding a match for an unsolved crime scene profile thus increases with the number of potential criminal profiles stored. The potential of DNA Databases to assist with investigations was immediately realized by the law-enforcement agencies using them. This success has an ongoing impact on the political standpoint, resulting in less restrictive legislation regarding the crimes or the persons for which DNA samples may be analysed and stored. It has also resulted in a considerable increase in database sizes over the last decade. The sizes of some of the existing databases are shown in the following table.

*Table 4: number of profiles in DNA Databases for INTERPOL member countries
(on your right)*

The total number of profiles provided as 'Reference' profiles is a combination of several categories: 'Convicted', 'Suspect', 'Victim' and 'Other'. A comprehensive analysis of DNA use and profiling categories around the world can be found on the INTERPOL restricted website **www.interpol.int** in the document entitled «INTERPOL Global DNA Profiling Inquiry- Results and Analysis 2008». Additionally, statistics on European DNA Databases are available on the public ENFSI website.

INTERPOL Member Country	Number of Profiles				
	Crime Scene	Reference	Missing Person	Unknown Deceased	TOTAL
Australia	97,705	276,237	30	15	373,987
Austria	32,000	117,150	103	61	149,314
Bahrain	?	?	?	?	?
Belarus	?	?	n/a	?	?
Belgium	14,000	14,000	n/a	n/a	28,000
Bulgaria	940	16,100	n/a	15	17,055
Botswana	?	1074	?	?	1,074
Canada	34,254	110,930	n/a	n/a	145,184
China	126,000	1,065,000	n/a	9600	1,200,600
Colombia	?	?	?	?	?
Croatia	2915	18,515	n/a	14	21,444
Cyprus	1,300	520	1,590	5	3,415
Czech Republic	4,560	12,786	20	211	17,577
Denmark	?	?	?	?	?
Egypt	30	320	n/a	1500	1850
Estonia	8,000	23500	15	35	31,550
Finland	9,517	68,030	n/a	n/a	77,547
France	34,014	810,336	130	200	844,680
Germany	135,252	571,250	972	438	707,912
Hungary	1,129	68,192	n/a	29	69,350
Iceland	?	?	?	?	?
Iran	n/a	n/a	n/a	?	?
Israel	25,000	4,180	n/a	n/a	29,180
Jamaica	50	2,607	0	2	2659
Japan	9,611	16,346	n/a	n/a	25,957
Jordan	2,435	11,666	1	2	14,104
Korea (Rep. of)	?	?	?	?	?
Kuwait	393	3958	n/a	n/a	4,351

INTERPOL Member Country	Number of Profiles				
	Crime Scene	Reference	Missing Person	Unknown Deceased	TOTAL
Latvia	?	?	?	?	?
Lithuania	1,464	11,301	?	n/a	12,765
Luxembourg	30	55	n/a	n/a	85
Macedonia, FYR	1,500	510	?	?	2010
Malaysia	300	?	n/a	n/a	300
Morocco	?	?	n/a	?	?
Netherlands	36,154	59,443	n/a	n/a	95,597
New Zealand	20,170	85,300	n/a	n/a	105,470
Norway	2,115	8,944	n/a	n/a	11,059
Panama	?	?	?	?	?
Poland	276	16,690	n/a	49	17,015
Portugal	?	n/a	n/a	n/a	?
Romania	38	7,000	n/a	n/a	7,038
Saudi Arabia	?	?	?	?	?
Singapore	?	?	?	?	?
Slovakia	3,400	8,370	29	267	12,066
Slovenia	5,000	11,000	?	?	16,000
South Africa	66,941	53,969	?	?	120,910
Spain	?	?	?	?	?
Sweden	?	?	n/a	n/a	?
Switzerland	19,245	99,217	95	101	118,658
Tunisia	?	?	?	n/a	?
Ukraine	176	1,723	n/a	n/a	1,899
United Arab Emirates	1,000	12,500	?	?	13,500
United Kingdom	329,660	5,093,145	n/a	163	5,422,968
United States	245,171	6,454,770	519	2,283	67,02,743
TOTAL PROFILES	1271745	15,136,634	3,504	14,990	16,426,873

THE VALUE OF A NATIONAL DNA DATABASE

A DNA Database relies on the principle that DNA obtained from the genetic material of a person or from biological evidence that is left at a crime scene is available on a database for investigative purposes. The underlying principle of a forensic DNA Database is that DNA from one source will give the same profile whether it comes from a crime sample or a reference sample.

A DNA Database therefore contains genetic information, in the form of DNA profiles, as records for people and crime samples. For different identity purposes, a DNA Database may contain different indexes for different identity purposes: for suspects, convicted offenders, volunteers, the general population, victims, police, laboratory personnel, local emergency staff (medical doctors, paramedics, firefighters etc), suppliers, missing persons and their relatives, unidentified bodies and mass screens.

A forensic DNA profile simply consists of a string of alphanumeric characters indicating the exact number of repeats at each of the STRs and information about the person's gender. When the alphanumeric code in two complete DNA profiles match, analysts can infer, not conclude, that they could have originated from the same source. The probability of observing two identical, full DNA profiles in two unrelated people is very low, less than one in a billion.

When new DNA profiles are loaded onto a DNA Database, the computer software compares these new profiles with the existing ones. A search will reveal any matches between the profiles added and the ones already present. Once this information is verified, it is then communicated to the investigating officer, purely as intelligence information.

An exclusion (non-match), inclusion (match), inconclusive or insufficient DNA result can be obtained (see *In the Laboratory*).

● USE OF THE RESULTS

DNA profiling, like other scientific evidence, can only indicate an association between the perpetrator and the crime. Therefore, any results require investigative police work to provide evidence and support the circumstances of the case. Consequently, all DNA results should be interpreted within the context of the case and with an understanding of the factors that will impact on the results.

In most countries, the custodian of the DNA Database is the Ministry of Interior, a State laboratory, or Special Police Force. The success of a DNA Database as an investigative tool is directly dependent on the number of DNA profiles it contains as well as a laboratory's capacity to analyse the biological evidence.

A DNA Database can contribute to the criminal justice system in the following ways:

- Different crime scenes can be linked and old cases solved when there are matches between crimes.
- Hits/matches enable investigators to identify serial offenders, perpetrators, co-ordinate investigations, and even share leads across jurisdictions.
- It ensures early identification, arrest of serial offenders and prevention of criminal activities.
- DNA can provide important investigative leads to help resolve issues of human identification.
- Cold hits from other laboratories or even other countries may link with a suspect from a completely different type of crime, years later.
- Crime prevention is the ultimate goal achieved through the deterrence effect of database sampling (i.e. “you should not commit a crime as we have your DNA profile - we’ll catch you!”).
- Familial searches on the DNA Database can result in the identification of the offender through links generated with the offender’s close biological relative/s.
- Police can spend more time on investigative work and focus on one or more individuals, whilst still performing a complete investigation in less time.
- Mass screening - having a large number of profiles for comparison on the DNA Database, is one of the main principles of a successful mass screen/intelligence-led DNA screen.
- The combination of DNA data and other forensic evidence can be invaluable in investigations, for example, when an unknown DNA profile is linked to the fingerprints of a known suspect.
- The use of an international DNA Database extends the scope of an enquiry and thereby facilitates criminal investigations.

● COLD CASE REVIEW — COLD HIT CAPACITY

“Cold hit” is a term used to define when a link is made between items of evidence that was not previously foreseen or anticipated. For example, when a DNA profile from Australia matches with a DNA profile from South Africa, it is unlikely that other evidence at the scene would have made this link, and subsequently a new lead is created. DNA can also create links many years after a crime was committed, even if they were not made at the time. This is due to the advances in forensic science and the technology that is being created. For a crime that was committed twenty years ago, the semen stain on a jacket might not have been sufficient to yield a DNA profile; however if that evidence has been properly stored and its integrity upheld, it might be used to create a DNA profile that may allow the case to be opened once again. The value of a DNA Database is that evidence from many scenes, individuals and time periods is stored, making the idea of a cold hit a possibility and the likelihood a reality.

Storage, continuity and review techniques for cold cases will vary greatly between countries and even between states within countries. However it is important to note that cold hits are one of the valuable uses of DNA evidence and consequently no evidence should be regarded as useless as future technology may prove otherwise.

ESTABLISHING AN EFFECTIVE DNA DATABASE OPERATION

An effective and dynamic promotional strategy is fundamental to the establishment and continuing success of national DNA Databases, as well as for enhancing the international exchange of forensic DNA profiles. Countries wishing to set up their own databases will gain the maximum benefit from their DNA Databases if they first develop their own promotional strategies.

Those countries which already have their own databases, or whose plans to set up a database are well advanced, will also find that this approach offers significant advantages. An effective promotional plan will maximize and maintain interest in the project, and funding for it, and create opportunities that may not previously have existed.

This section will provide ideas and information on various promotional activities that have proved useful in countries that have already developed their own databases. It will also outline a suggested promotional plan that incorporates the key elements for a successful strategy.

● IDENTIFYING THE OUTCOME

Publicizing and promoting any activity first requires a clear understanding of the outcome. In the case of a national DNA Database, understanding, and therefore awareness, of its potential benefits for any country is likely to vary widely depending on personal knowledge and any particular responsibilities.

In some countries, the level of awareness among the general population may be very low or non-existent. A higher level of awareness may be confined to law-enforcement personnel, and the scientific community in universities and forensic laboratories. Politicians, in particular, may be unaware of the scale of potential advantages for their criminal justice systems, and the cost benefits a DNA Database can provide in the investigation of crime.

In other countries, the overall level of awareness may be much higher but the political interest in a database may not match that level of awareness. As a result of this, there may be a lack of progress, with inadequate funding and lack of suitably qualified and experienced personnel often being key factors. Where sufficient funds have been made available, or where there is already political interest, effective promotion will serve to further heighten awareness wherever necessary.

Consequently, identifying the outcome may involve establishing a primary level of awareness amongst the target audience (see *below*) to create a demand for a database. For example, to gain the interest of a legislature that has previously resisted the idea of setting up a database, it may only be necessary for those who are knowledgeable on the subject (e.g. forensic scientists and police officers) to lobby politicians and thus create an awareness of the subject.

● LEVEL OF AWARENESS

The primary level of awareness will be different for each target group. For instance, politicians will not have the same requirements as police officers. Political considerations and the wider interests of justice, privacy and civil liberties may be paramount for a government but of less direct interest to those responsible for the investigation of crime. Police officers are likely to be more attracted to the practical benefits that a database can offer, such as the speedy elimination of suspects or the significant increase in the evidential value of crime scene material.

Countries that have not yet considered establishing a database are therefore urged to engage with all parties concerned to create a primary level of awareness, particularly among politicians and senior police officers.

In the case of politicians the aim should be to obtain a commitment to introduce any necessary legislation and then ensure that the commitment is kept. Senior police officers have a key role to play during this phase. Some may themselves have little knowledge of the benefits of a database and may need to be “educated” before they can, in turn, have an impact on politicians.

● MEDIA INTEREST

The media have an important role to play at this stage. It is likely that they will be aware of high-profile cases in other countries where the benefits of DNA technology have been obvious. They can usefully create pressure in support of the view that a database is not just desirable but essential for all INTERPOL member countries.

Providing the press with details of successful cases from other countries may be particularly helpful. This, coupled with briefings on progress and new developments, will maintain a high public profile for the topic.

● «THE CSI EFFECT»

Popular television programmes such as “CSI” and others of the same type have had a beneficial effect, in the sense that public awareness of forensic DNA has markedly increased in recent years. As a result, education and promotion of the basic concepts underpinning forensic DNA and DNA Databases is not likely to be required as much as it once was. However at the same time, such shows seem to have had the effect of raising courts’, and in particular jurors’, expectations as to the speed and effectiveness with which forensic DNA can solve crimes. Care is required to counter such artificial perceptions, and to ensure that expectations are managed so as to be kept at a realistic level.

● NEED FOR A DNA DATABASE

Once the basic need for the database has been established, other groups may have to be targeted to raise their awareness of the benefits of a database and of its advantages for civil society. The general public should not be left out of this process. Therefore, creating a realistic awareness that DNA technology can be a very effective weapon in the fight against crime can make the public a powerful ally, as everyone is a potential victim, but the potential benefits should not be oversold.

● TARGET AUDIENCE

Having identified the outcome in the eyes of those who are in a position to initiate change, the focus of attention can then turn to identifying, and impacting on, those target groups that may be able to lend their support. This reflects the experience of using DNA Databases of certain highly developed countries in this field, and is considered vital to this phase of the process.

The level of awareness within any criminal justice system will vary enormously and each group of people concerned will have different requirements. The following groups can be identified:

Medical Personnel

Doctors who are employed by the police, including pathologists involved in post-mortem examinations, may be unaware of recent developments in DNA technology, and in particular the low level of biological material now required for profiling or, in appropriate cases, LCN Analysis. It is essential to ensure that all samples are collected in the most satisfactory way, in all appropriate cases.

Investigators

The police will be the principal beneficiary when DNA technology is used to assist criminal investigations. But it is not just senior police officers that should be aware both of its potential, and of the practical aspects of crime scene sample collection, chain of custody safeguards and database operational requirements. Crime scene officers (both police and civilian) may require initial and ongoing training. The day-to-day practicalities of using DNA technology as an investigative tool should also become a standard item in the training given to new police recruits.

Senior officers can be powerful allies in this regard and they can lobby politicians very effectively. They should therefore be strongly encouraged to create a “DNA culture” within their police services, and within wider justice departments.

Scientific Establishments

Scientists and staff at forensic laboratories, together with lecturers and students at university departments teaching related subjects will all benefit from the input of other professionals, such as police officers and prosecutors who use DNA technology in the course of their investigations. A likely high level of awareness and interest among university students can be enhanced in this way to promote the subject in whatever field of science they undertake as a career, thereby creating a further demand for both improvements and maximum usage.

Judges and Prosecutors

Judges, court staff, prosecutors, defence attorneys and other officials in the trial process vary widely in their level of awareness of forensic DNA concepts, techniques, and issues. Accordingly, they will benefit from:

- Personal briefings
- Publication of articles on DNA technology in their professional journals
- Involvement of DNA scientists in their forensic training
- Regular meetings with prosecutors to promote the value of DNA in ongoing and future investigations

● GENERAL PUBLIC

As DNA Databases are a relatively new development, and often perceived to be part of a wider “surveillance society” trend, the public at large may fear a threat to their personal privacy and lawful activities. Promoting the positive aspects of DNA as an investigative tool is an effective way of minimizing any fears that DNA may pose a threat to civil liberty and natural justice. It needs to be understood and stressed that the greatest application of DNA technology is the elimination of innocent persons who had been suspected of being involved in a crime. Some consideration should also be given to ethical issues, notably clarification of the use of non-coding regions (see *Geographical Search, Phylogeny, Physical Characteristics and other uses*).

Positive briefing of the media will help counter any such fears. Ensuring that successful prosecutions in high profile cases are given maximum publicity will create a wider understanding of the incontestable aspects of the science. Lectures by DNA scientists and other practitioners to a range of public organizations will also be helpful.

New Techniques

Care needs to be taken with the application of new techniques, such as ethnicity profiling and familial searching, to avoid creating situations where challenges to both the evidence obtained, and the databases operated, within a country are mounted, due to conflicts, intentional or otherwise, with human rights and privacy standards enshrined in a country’s legal system.

Publicity

Once a database has been established and is in operation, the need for effective publicity still exists. For example, politicians will need to be reassured that their money has been well spent and that the best possible value for money has been achieved. The lack of immediate results may require regular explanation.

● EVIDENCE

Judicial officers and lawyers (particularly defence lawyers) may challenge DNA evidence. As a result:

- Chain of custody evidence needs to be thorough and valid.
- Laboratory procedures need to withstand scrutiny both as to the actual procedures used and the documentation of such procedures.
- Scientific expert witnesses presenting DNA evidence in court must therefore ensure that the evidence presented is robust and presented in accordance with relevant current research.
- Strict compliance with applicable local legislation needs to be maintained throughout, and documentary evidence of such compliance available.
- If a probabilistic approach is adopted, then the validity of the underlying population databases needs to be established.

An intelligence database can only be effective if it contains unsolved crimes that are systematically and regularly compared against offenders' samples. This needs to be understood by the police, who therefore will be responsible for collecting not only samples from individuals but also those from crimes.

The following are recommended as options:

- Training material such as videos and reference books;
- Posters for both public and specific audiences;
- Media briefings;
- Internal (police) publicity of DNA cases of particular interest;
- Visits to DNA laboratories;
- Articles in professional journals;
- Presentations to interested groups;
- Publication of a DNA newsletter (particularly useful as a database is set up)
- Management information for the police on the effectiveness of different samples from either crime stains or from offenders;
- Proactive education of investigating officers about new developments.

PRIVACY AND DATA PROTECTION

While the benefits of DNA technology and databases are undoubtedly overwhelming, restrictions on their use are required. Restrictions should be well defined in terms that guard the privacy and social concerns of the individuals, within the international framework of law.

The key concerns regarding DNA data storage are social in nature and often arise from fear that unauthorized access may lead to a violation of an individual's right to privacy and right to life. It is, therefore, important for every government or law-enforcement authority to dispel such fears and effectively guard the confidentiality and privacy of every individual within the framework of law.

The fundamental principle which outlines the storage of such personal data is that genetic information should be obtained by fair and lawful means and utilized for the purpose for which it has been collected. Therefore, policies should be considered which concern the appropriate circumstances for DNA collection and methods by which it can be collected. Limits for the use of the data and the sample should also be established. Personal genetic data must be protected from unauthorized access and use by security safeguard. Any deviation from the basic principle is bound to raise concerns that can have serious ramifications.

● WHAT CONCERNS EXIST AND WHY?

Due to the fact that DNA can provide insight into individuals' intimate personal details, social concerns arise. Such information is more intimate than that revealed in other forensic and scientific methods used in investigation such as fingerprints, footprints, photography, handwriting etc. DNA can not only provide intimate information on individuals, but also on their families.

The fear of such intimate information on an individual/family being misused and exploited is the reason for concern. Reckless legislation and practices adopted by law-enforcement agencies in the collection of such DNA samples and not protecting them adequately would infringe upon an individual's privacy and right to life.

● SOCIAL DISCRIMINATION

There is potential for the intimate details that DNA can provide about an individual to be misused by law-enforcement authorities, employers, insurers, or even the government. The misuse of this sensitive data can lead to discrimination and result in the isolation and stigmatization of individuals or groups of individuals. The fear of discrimination based on the information that DNA contains is a social concern that needs to be addressed for there to be confidence in DNA Databases and DNA collection.

It is not only the individual who is involved in a crime or investigation who may be affected by discrimination due to results from DNA tests. The family members of the individual may also be at risk. This is due to the similarities that exist in the genetic make-up of family members. The DNA of an individual can reveal his personal and family disposition to illness and disease. Discrimination on the grounds of genetic predisposition to diseases, temperament, and many other traits determined by our DNA, often gives cause for concern. There is potential for links to be made between a profile obtained at a crime scene and a family member of the perpetrator who has already been convicted, making it possible for families to feel unfairly targeted. These factors can affect the public's confidence in a national DNA Database and give rise to concern.

A major social concern is linked to the health-related information that can be determined from DNA; disclosure of this kind of information can make an individual feel vulnerable to discrimination in employment, education, insurance and other contexts. Use of information that relates to an individual's health predisposition by insurers when fixing insurance rates would stigmatize and discriminate against individuals in society. With many aspects of health, DNA is not the only contributing factor; so an individual might even feel forced to undergo health checks and prove the absence of the illness so as to avoid such discrimination. This treatment could result in mental agony and financial loss alongside unfair stigmatization.

Whilst bearing in mind the possible misuse of DNA data for the harassment of an individual, it is essential that every effort is made to ensure that the genetic data is handled within the framework of international conventions and declarations. The genetic data should be safeguarded and protected to prevent its use as a tool for discrimination by employers, insurers, and so forth. Similarly, efforts should be made to ensure that DNA data is not misused for purposes of discrimination and categorization.

● ADDRESSING PRIVACY AND DATA PROTECTION CONCERNS

Law-enforcement agencies and other relevant authorities should aim to protect individuals' genetic data. Standardization of procedures that concern the collecting, processing, utilizing and accessing of the genetic data should be a high priority. All efforts should be made within international standards to ensure fairness, and transparency and integrity of the DNA information collected and stored by the law-enforcement agencies.

To effectively prevent the misuse of DNA information for unauthorized purposes it is important to educate all personnel involved in the collection and storage of DNA data. This will ensure that at each stage everyone involved with the data is aware of the privacy and safety provisions of the law and will subsequently help improve the protection of innocent individuals. Protecting the public's right to privacy is of paramount importance.

Strict and stringent laws should be in place to prevent any misuse of DNA information so that discrimination based on racial, ethnic, religious or health reasons is not permitted by insurers, employers, law-enforcement agencies or anyone else concerned.

● CONCLUSION

The rights and welfare of an individual should be balanced against the interests of society. It is the responsibility of the government to ensure that human dignity and human rights are protected when dealing with human genetic data. Equality, justice and privacy legislation should conform to international laws on human rights and should be referred to when genetic data is involved. DNA databasing legislation and policy should observe and consider international instruments, such as:

- Universal Declaration of Human Rights (1948)⁶
- United Nations Educational, Scientific and Cultural Organization (UNESCO), Universal Declaration on the Human Genome and Human Rights (1997)⁷
- UNESCO International Declaration on Human Genetic Data (2003)⁸
- UNESCO Universal Declaration on Bioethics and Human Rights (2005)⁹

Specific legislation is not an absolute requirement to start DNA profiling, collecting DNA data, establishing a national DNA Database or exchanging data internationally. National laws may allow DNA profiling, but it may be that it is not specifically mentioned in any legislation. Investigative tools such as DNA profiling may be covered in umbrella terms that allow their use in investigations without this being mentioned outright. Many countries started experimenting with DNA Databases without specific laws, and subsequently developed specific legislation later.

However, most countries established specific legislation prior to the installation of national databases. The details of the legislation are essential, as inadequate laws may condemn a national database to be unsuccessful.

What does the term 'success' mean for a national database? What are the issues? And what are the reasons for having a DNA Database? A successful database can result in the prevention of crime and can contribute in solving crimes.

In fact, both fundamental areas of contribution cannot really be separated and a national database will support both the prevention and the investigation of crimes.

One essential point for consideration that affects the success of a DNA Database is the decision as to which profiles will be included. Can reference samples only be taken from convicted persons? Or can they also be taken from suspects and arrestees? If only convicted persons' profiles are included, then society might perceive that everybody has carte blanche to commit their first crime, due to the fact that prior to conviction there will be no risk of being caught by a cold hit, as there will be no reference sample present in the database. However, including profiles of suspects might allow society to perceive that a sample taken from an innocent person could later be used to incriminate that person for a different crime. This dilemma, as to which profiles to include, is one that has to be resolved. An overview of national databases worldwide clearly shows that all successful DNA Databases include profiles of suspects and convicted criminals.

Another crucial decision that needs to be made for a DNA Database to be successful is as to the kind of crime which warrants the taking of reference samples. The simplest and most efficient method is to include all crimes that may lead to an arrest. However another option is only to take samples for crimes carrying sentences of more than a certain minimum period of imprisonment. It would also be possible to draw up a classification or list of crimes, for example "all serious offences", and only take reference samples from selected class or classes. Different countries have different methods; however all countries with successful databases take samples for all crimes, including volume crimes. The reason is that DNA profiles from serious crime scenes mainly produce matches with reference samples taken from suspects or offenders who have committed volume crimes prior to or after committing the serious crime.

Should DNA profiles be removed? Again, the spectrum of rules ranges from profiles never being removed, being removed after a certain period of time, or else varying, depending on the crime, on an individual prognosis for the convicted, or on the age of the person. If suspects or arrestees are included in a national database, an additional exit mechanism should be included, for example if a person is no longer a suspect or if an accused person has been acquitted by a court, then the relevant sample is removed. Inclusion of a deletion mechanism as described will not have a negative influence on the success of the database. However it may be helpful in improving the acceptance of the DNA Database by the population, as it diminishes some of the concerns held by many.

In most countries restrictions regarding the inclusion of crime scene stains in national databases are set by financial limitations rather than by legislation. In most cases, the same is true with reference samples, but wherever possible volume crimes should be included to increase the chance of matches with serious offences and offenders. Most countries keep crime scene profiles as long as they remain unsolved or when a court order demands their removal.

The procedures for removal of profiles from the database and sample destruction need to be defined. The authority required to order removal should be addressed. Legislation should also define who is to be allowed to take a reference sample, and on what grounds. The procedural requirements must be followed to safeguard the legality of the sample. However, in constructing this legislation it is important not to introduce unnecessary obstacles into the sample collection process that will impact on the efficient collection of samples. The most efficient solution is that a police officer or appropriately trained professional should be able to take the sample and it should not be necessary to obtain a magistrate's or mandatory court order.

Additional databases are useful and may also be ruled by legislation. This includes databases containing laboratory information, personal information, police elimination profiles, victim profiles or profiles for innocent people living near the scene of a crime or for emergency staff etc. Precautionary rules should be defined so that these databases are not mixed with the criminal databases, but are only used on a case-by-case basis. The same is true if the national DNA Database is used for identifying missing persons or recovered unidentified bodies. Profiles obtained from family members of missing persons should not be mixed with the criminal database.

A potentially important application of DNA profiling is through an intelligence-led mass screen. This application does not usually require use of the national DNA Database. However, a question may arise as to whether samples collected through an intelligence-led mass screen should be subsequently entered into the national DNA Database.

Any national law on DNA should also include regulations on international DNA data exchange. The INTERPOL DNA Gateway success stories show that the additional efforts necessary for international exchange are minimal, yet the positive effect can be enormous, in terms of matches that could never have occurred otherwise.

In conclusion, legislation has to find an adequate balance between the interests of the individual and the interests of society. It must be in line with constitutional rights and other legislation, including privacy and data protection aspects, but without unnecessary restrictions. The most important resource in the use of DNA in most countries is legislation. Many amendments in national legislation have been observed world-wide over the last few years, and there is no way of knowing how many crimes could have been prevented if appropriate legislation had been in place from the beginning.

Whilst not typically covered in legislation, it is also important to give a similar level of detailed consideration to sampling and analysis strategies with regard to crime scene attendance and evidence recovery. It can be shown that increased overall success of DNA Database programmes results from an increased focus on both crime and person sampling.

● OTHER FACTORS

The success of a database does not only depend on the legal basis. There are a variety of factors which may impinge on the effectiveness of this investigative tool. The ENFSI (European Network of Forensic Science Institutes) DNA Working Group recently published a document entitled *DNA-Database Management – Review and Recommendations* that deals with many of the aspects that professional users have experienced. A number of recommendations including explanatory background information are compiled in the document (see *Appendix 7*). Although some aspects focus on the situation in Europe, most of the topics dealt with are of general use regardless of the legislation or the region of the world.

THE POTENTIAL OF DNA

THE USE OF POST-CONVICTION DNA TESTING; THE UNITED STATES' EXPERIENCE

Forensic DNA testing and state and national databases have been used retrospectively to re-examine evidence from historic, unsolved offences originating as far back as the 1970s. In some circumstances this analysis has not only identified a suspect for the crime in question, but has proven the innocence of an already incarcerated person. In the United States through the New York (NY) Innocence Project¹⁰, based at the Cardozo School of Law, NY, 217 persons have been exonerated (at 1 June 2008) following DNA testing of exhibits related to their original convictions. Collectively these men have served over 2,500 years in prison for crimes that they never committed, with the average jail term being in excess of 12 years. In 16 cases the death penalty had been imposed before an individual's innocence was proved. About 70% of those exonerated were members of minority groups. Additionally, in over 35% of cases involving post-conviction DNA exoneration, the true perpetrator was also correctly identified through the use of DNA testing.

As of July 2007, 42 states of the United States had some form of law permitting inmates' access to DNA testing, with the remaining eight states having no law granting such access¹¹. The legislative models vary in the extent of provisions they afford to inmates seeking DNA re-testing. In some states all incarcerated felons are granted access to post-conviction DNA testing with the associated costs borne by state authorities. In others there are restrictions on the eligibility of certain inmates; for example, those who pleaded guilty or whose lawyers failed to request DNA testing at trial. In some models there are time limits on when an application can be made and the petitioning inmate must meet the cost of re-analysis. In some cases, the controversial evidence that was used to convict a defendant at trial – such as eyewitness identification or “snitch testimony” – can also be used as grounds to deny a DNA test. As with all laws there is a need to strike a balance between the rights of incarcerated felons to have their convictions reviewed and the potential for misuse of state resources and the protracted continuation of criminal matters.

An important outcome of the numerous cases of post-conviction exoneration is the ability to review the original cases and determine what led to the incorrect initial verdict. Saks et al.¹² and Liebman et al.¹³ both presented data on failings identified following post-conviction review. Saks et al. cited data from 81 cases of wrongful conviction and reported that eyewitness identification (60), inadequate legal representation (55), and erroneous forensic science (53), were the features that most commonly led to wrongful convictions. Liebman et al. focused only on capital cases and reported that “egregiously incompetent defence lawyers” accounted for 37% of the post-conviction

reversals, whilst prosecution suppression of evidence that the defendant was innocent accounted for another 16% (or 19% if cases of inappropriate application of the death penalty are included). The erroneous forensic science associated with wrongful convictions commonly involved antiquated techniques that were relied upon 20 to 30 years ago, misinterpretation or over-interpretation of results, statistical exaggeration, or, in some cases, fraud or gross misconduct. It is difficult for the justice system to identify forensic misconduct as doing so often relies upon someone with specialist knowledge having access to the original data and exhibits. This is a tacit reminder that the forensic community itself has a heavy onus of responsibility to ensure the quality and transparency of findings presented in court.

The revelations of programmes such as the innocence project provide an example of the potential for DNA testing to uncover the truth – whether it does so on the ‘side’ of the victim or their wrongly convicted attacker. However, it is important that we also remember that DNA is simply another example of forensic evidence. Whilst it allows a high level of certainty regarding its conclusions, it is not infallible and does not have the same effect when used in a stand-alone capacity, in the absence of support from investigative outcomes or other forensic evidence. Also, obtaining meaningful DNA evidence relies on the accurate localization of biological material at the crime scene and the demonstration of appropriate chain of custody and procedural handling of the subsequent analysis. Operating in this way is commonplace in contemporary investigations; however, it is less assured in historic investigations and in some cases the lower level of rigour applied through outdated practices can jeopardize the usefulness or admissibility of forensic evidence recovered later using contemporary techniques¹⁴.

For post-conviction testing to be of future use it is incumbent that all relevant evidence be collected and stored appropriately so as to allow for subsequent re-analysis. Again, it is necessary to strike a balance between collecting and storing everything indefinitely, and destroying vital items of evidence too hurriedly. This is another area to be considered in post-conviction legislative models and in best practice policies and procedures for police and forensic agencies.

The realization of the ability of a ‘new’ technology like DNA to provide greater clarity and certainty in historic investigations tells us something else about our field of science. That is, that we should continue to strive to adapt and develop our technical capability. The impressive outcomes of post-conviction use of DNA testing provide a stark reminder of how the technologies of tomorrow may well provide the ability to reflect with more clarity and certainty on cases occurring today.

The idea that a DNA Database could be used to identify a close relative of the perpetrator was foreseen during the initial evaluation of forensic DNA technology. In the United States, the National Research Council described this issue in their first published report:

“When a biological sample is found at the scene of a crime, the DNA pattern can be determined and be made compatible with a databank. If the unidentified DNA profile perfectly matches a sample in the convicted-criminal databank at enough loci, the probable perpetrator is likely to have been found. However, a different outcome could occur: the sample might match no entry perfectly, but match some entry at about one allele per locus. Depending on the number of loci studied, one could have a compelling case that the source of the sample was a first-degree relative (e.g., brother) of the convicted criminal whose entry was partially matched... Such information could be sufficient to focus police attention on a few persons and might be enough to persuade a court to compel a blood sample that could be tested for an exact match with the sample. To put it succinctly, DNA databanks have the ability to point not just to individuals but to entire families - including relatives who have committed no crime. Clearly, this poses serious issues of privacy and fairness. As we point out more fully later (see *Privacy and Data Protection*), it is inappropriate, for reasons of privacy, to search databanks of DNA from convicted criminals in such a fashion. Such uses should be prevented both by limitations on the software for search and by statutory guarantees of privacy¹⁵.”

This issue had remained in the background in most countries with the exception of the United Kingdom and the United States. Since the United Kingdom and United States maintain two of the worlds’ largest investigative or offender DNA Databases, the debate in both of these countries is not surprising.

Most countries implement DNA Database programs to store DNA profiles of specific categories of offenders or suspects, with these categories expanding over time. In general, the initial offender databases covered violent and sex offenders. Today, most databases include all felony offenders and there is a growing trend to include persons arrested for specific offences and suspects. Now that the DNA Databases have grown in size, the efforts to fully exploit the power of these investigative DNA Databases are increasing and the issue of “familial searching” is receiving significant attention.

The United Kingdom’s national DNA Database (NDNAD), operated by the Forensic Science Service (FSS), is the only database to have an active “Familial Searching Program.” A familial search must be approved by the Association of Chief Police Officers (ACPO - an independent body that co-ordinates police services in England, Wales and Northern Ireland). Searches are considered when all investigative leads are exhausted and the search requires payment of a fee. “Familial searching” is credited with solving approximately two dozen cases in the UK since its introduction¹⁶.

Familial searching is not performed in the United States National DNA Index System (NDIS) operated and maintained by the Federal Bureau of Investigation (FBI). However, one state, California¹⁷, announced that it would begin a familial search program of its State Offender DNA Database in late 2008. Another state, Maryland, has recently legislatively banned “familial searching” of its State DNA Database. The Maryland law provides that: “A person may not perform a search of the state-wide DNA Database for the purpose of identification of an offender in connection with a crime for which the offender may be a biological relative of the individual from whom the DNA sample was acquired”¹⁸.

Most database hits occur between offender samples and crime scenes. The database software that directly compares DNA from crime scenes and individuals is designed to return identical matches and to also allow for some mismatching between DNA profiles. Mismatching is permitted because the crime scene DNA can be degraded and/or contain DNA from two or more individuals. A familial search would only occur after the routine search of an offender DNA Database produced no candidate matches.

Familial searching is predicated on the genetic relationship between family members, whereby one allele at each locus is contributed by the mother and one from the father¹⁹. Thus, the presence of a large number of shared alleles between non-matching profiles (non-matching because it is not an identical match), indicates that a close relative of the individual whose profile is on the database may have been involved in the crime. “Familial searching” is a second, deliberate search of the DNA Database at a lower stringency. It is done in order to identify DNA profiles of known individuals (offenders, arrestees or suspects) that are not an identical match to the crime scene DNA profile but may match a significant number of alleles as to lead the forensic scientist to believe that the suspect is a close biological relative of the known individual.

The term “familial searching” is frequently used in conjunction with “partial matches.” “Familial searching” is not the same as a “partial match.” In the US, serious debate has occurred concerning “partial matches.” Unlike familial searches, “partial matches”; are not deliberate searches to identify possible relatives of the perpetrator. “Partial matches” are the identification, by a forensic scientist, of DNA profiles from different individuals that have significant profile similarity. “Partial matches” are the consequence of the database search algorithms that allow mismatching between crime scene and offender profiles. As noted previously, some DNA software can be configured to allow mismatching in an effort to ensure matches are not missed due to degradation or mixture resolution.

Therefore, a “partial match” is a fortuitous event identified by a forensic scientist who, when evaluating the candidate match from a routine DNA Database search, determines that the two DNA profiles do not match but, because of the similarity in the profiles and the number of common alleles, indicates that a close biological relative of the offender may be linked to the evidence. In the US, it is left up to each state to determine if they will release information relating to a “partial match” to the investigating agency. The National DNA Index System administered by the FBI has a mechanism for a case specific review of “partial matches” identified at the national level.

“Familial searching” has its advocates and critics. Law-enforcement officials strongly support more routine use of this searching technique in an effort to solve more crimes. One study theorized that “familial searching” could increase a jurisdiction’s investigative lead rate by 40%²⁰. Law enforcement officials encourage the use of this tool as demonstration of their commitment to, and responsibility for, the victims of crime. The law-enforcement officials endorse the use of “familial searching” as an additional investigative mechanism in serious cases (murder, sexual assaults) in which there are no other leads to pursue and there is a serious concern regarding public safety.

There have been objections to this technique as a violation of the privacy rights of families²¹. In addition, objections are raised on the basis that familial searching is an unauthorized use of the DNA collected from offenders and arrestees, as its original purpose was for their identification. Others have raised concerns about the potential racial injustice in extending searches of these DNA Databases that are disproportionate to the racial composition of a country’s population, to the families of those represented in the database²².

In addition to the ongoing debate between law-enforcement officials and privacy advocates, as a practical matter, most of the software used to operate criminal investigative DNA Databases does not currently contain all the capabilities needed to fully analyse the kinship relationships and provide relevant candidate matches. Current “familial searching” of the investigative DNA Databases results in lists of numerous candidate matches because the searches are conducted at a lower stringency intended to produce candidate profiles matching at fewer loci. A list of hundreds to thousands of individuals can be generated from a single familial search. Additional guidelines for pursuing the investigative leads generated from “familial searching” will be needed to address a number of issues, including sensitivity to potential differences between social and genetic families. How to use and follow up on the information generated from the familial search are important issues that should be addressed by the law-enforcement agencies that use this technique²³.

This, and other uses of these offender DNA Databases, will continue to evolve. As the privacy and ethical issues are resolved through legislation, case law or other appropriate authority, strategies for more effective kinship analysis capabilities will be developed which, when used in conjunction with a comprehensive investigative scheme, may yield a supplementary DNA Database tool for law enforcement.

GEOGRAPHICAL SEARCH, PHYLOGENY, PHYSICAL CHARACTERISTICS AND OTHER USES

The information in the following section is not linked to the current use of forensic DNA Databases. It represents a future potential use of DNA that does not rely upon comparison with collected profiles but where the DNA profile itself, obtained through other genetic markers, may provide investigative support but does not lead to an identification by itself.

The present capacity of forensic DNA technology is impressive; however progress in molecular biology is increasing the range of genetic markers available for forensic purposes. This has exciting potential for the use of forensic DNA results in investigations. Specific examples of this diversification include more widespread use of Y-chromosome or mitochondrial DNA (mtDNA) markers (known as non-autosomal markers) or new marker types such as single nucleotide polymorphisms (SNPs). These target regions offer the possibility to produce a DNA profile that indicates information about the biogeographical ancestry of the donor, or information regarding certain personal or physical characteristics.

GEOGRAPHIC SEARCH, PHYLOGENY

The mitochondrial genome and the non-recombining region of the Y chromosome represent the only two haploid regions of the human genome as both are transmitted uniparentally, with no recombination²⁴. This lack of recombination means that the Y chromosome and the mitochondrial variants show greater levels of geographical affiliation than profiles obtained through routine autosomal DNA testing.

Refining applications for non-autosomal DNA profiling has been of considerable value to the forensic field as it has increased the investigative relevance of the techniques and added to the capability of casework laboratories. MtDNA has been extensively used in human evolution studies for a number of years²⁵ and is particularly suitable for this application due primarily to the fact it is inherited down the maternal line (from mother to child). In forensic science mtDNA is most often analysed in circumstances where routine DNA tests fail to give a result. These commonly include the identification of telogenic hairs²⁶, nail material²⁷ and bone (associated with missing persons' cases)²⁸. It is also used in cases where distant relatives are the only available source of reference material, such as in historic investigations or cold cases.

Recent progress in the forensic use of mtDNA has been brought about by the context in which it has been acquired more than through technological breakthroughs. For example, in response to the European refugee crisis, Spanish forensic authorities formed a non-criminal mtDNA Database to assist in the identification of remains and investigation of this serious social issue²⁹. Likewise in the United States, the automation of mtDNA techniques played a role in the identification process that followed the World Trade Center (WTC) tragedy^{30,31}. The social benefits brought by these initiatives highlight the role mtDNA analysis can play in non-criminal or coronial investigations, particularly where repatriation of human remains is the key objective.

Because mtDNA is only inherited down the maternal line there is a direct similarity in the mtDNA sequences of mother and child. At a population level, this pattern of inheritance shows up as a reduced diversity among mtDNA haplotypes of members of the same population group. In this way the mtDNA haplotype observed in a sample can be indicative of the donor's ethnic background as individual mutations are quite rare but over time have accumulated in different parts of the mtDNA as modern humans dispersed to different parts of the world. Many published studies have analysed specific ethnic populations or geographical groups to determine the most common mtDNA haplogroups observed. These studies range from analysis at a continental level down to studies at a community or tribal level. The continental origin of at least 70% of African, European, Asian and Native American mtDNAs has been determined³². Information on forensic mtDNA including a major database of population haplotypes is available through the EMPOP website www.empop.org³³ which has been established and endorsed by the European DNA Profiling Group (EDNAP)³⁴.

The analysis of polymorphisms on the Y-chromosome has also developed into a valuable forensic technique³⁵. The male specificity of the Y-chromosome makes it particularly suitable for the resolution of problematic situations such as complex mixtures and kinship investigations. In casework settings, Y-chromosome analysis is especially useful for typing mixed male-female stains that commonly occur as a result of sexual assault on a female victim by a male offender. Selective targeting of the male (Y) DNA removes the prospect of the female DNA swamping the PCR and allows unambiguous determination of the male profile (which in this case is a Y haplotype).

As with mtDNA, forensic exploitation of molecular variation on the Y-chromosome is not new^{36,37}; however, refinement, standardization and sophistication of the core methodology has increased the casework suitability of the technique^{38,39,40}. Y-STR multiplexes have been constructed and are available as commercial kits (see Table 5). Forensic laboratories utilising Y-chromosome analysis are encouraged to follow recommendations of the International Forensic Y Users' Group regarding loci and nomenclature and to contribute haplotype data to informative research databases^{41,42}.

YEAR OF RELEASE	NAME	N° OF LOCI
2002	Y-PLEX™ I2	12
2003	Promega PowerPlex Y	12
2004	ABI AmpFISTR® Yfiler™	17

Table 5. Commercially available Y - chromosome tests

There is also potential of Y-specific haplotypes to demarcate the population of origin of a donor of a biological sample. This is because the Y-haplotype represents the history of the male lineage of the donor. Population signatures from Y-chromosome haplotypes tend to be more discriminatory than those derived from mtDNA – although they have the disadvantage of only being able to be derived from male samples. The added local diversity has been attributed to social practices such as patrilocality. Patrilocality is a practice evident in approximately 70% of modern human populations that describes the movement of women to the man's place of residence after marriage. This results in less geographical differentiation of maternal lineages, and increased differentiation of the male specific Y chromosome^{43,44}. This level of inference is obviously of forensic interest^{45,46} and as the level of use of Y-chromosome testing increases, this capability will no doubt be further explored. Major internet-based population databases currently exist and users can search the haplotype of casework samples and observe the frequency of its occurrence in other population groups provided from around the world. These websites also offer additional features such as assistance with statistical interpretation. The major examples have been listed below:

Y Chromosome Haplotype Reference Database (YHRD)

(available at <http://www.ystr.org/index.html>)

PowerPlex® Y Haplotype Database

(available at <http://www.promega.com/techserv/tools/pplexy/default.htm>)

Applied Biosystems® Yfiler Haplotype Database

(available at <http://www.appliedbiosystems.com/yfilerdatabase>)

ReliGene Y-STR Haplotype Reference Database for U.S. Populations

(available at http://www.religene.com/index.asp?menu_id=rd&content_id=y_freq)

SNPY Reference Database

(available at <http://www.snp-y.org>)

The most informative target loci for attempting to determine phylogenetic or biogeographic origin are single nucleotide polymorphisms (or SNPs). SNPs can be found in areas of the genome that are subject to selective pressure, such as coding and regulatory regions. This means that they exhibit greater allele and genotype differences between populations. Also, SNPs have a very low mutation rate meaning it is likely that the same or similar SNP genotype will be passed from one generation to the next.

To date, the need to adhere to STR typing (due to the value of existing databases) and the lack of individual diversity has delayed broad adoption of SNP technologies into forensic science. However, the abundance of SNPs and progress in SNP genotyping technology will eventually ensure that forensic systems evolve to incorporate these polymorphisms. SNPs have been analyzed on the mtDNA and the Y chromosome for some time⁴⁷. Progress with autosomal SNPs suitable for forensic purposes was foreshadowed in 2001 and large SNP multiplexes now exist for forensic identity testing⁴⁸.

DNA markers that show an affiliation with population origin are often referred to as ancestry informative markers (or AIMs). By using a panel of AIMs it is possible to infer the biogeographical origin of an individual. Such DNA-based tools could be used early in an investigation, before suspects are identified, and would be highly advantageous to narrow the pool of potential suspects. This would allow more efficient use of police and forensic resources and objectively assist decision-making early in an investigation. There is also potential to use such techniques in large-scale victim identification cases, particularly in circumstances where there is no manifest of missing people and forensic analysis is tasked with proposing possible explanations in the hope of leading ultimately to identification.

An SNP-based technique for classifying ethnicity was reported in 2003⁴⁹. Using a panel of 56 SNPs (mostly from pigmentation genes) it was reported that the test could successfully designate the ancestry of European, African and Asian donors with 99%, 98% and 100% accuracy. Applying a reduced panel of the 15 most informative SNPs the level of accuracy reduced to 98%, 91% and 97%, respectively. This work represented a significant step towards the development of a DNA-based test for the inference of biogeographical ancestry and led to the development of a commercially available product known as DNA Witness™ (DNA Print Genomics, Sarasota, FL). The most recent version of this product DNA Witness™ 2.5, includes subsidiary products Euro Witness™ 1.0 (a test that determines more specific geographic origins by providing relative percentages of Northwest European, Southeast European, Middle Eastern or South Asian) and RETINOME™ (a test for iris colour).

Regardless of which tests are applied to infer biogeographical ancestry (mtDNA, Y-chromosome or SNP-based tests) it is important to note that:

1. These tests are designed as intelligence tools, operating as a preliminary screen that should reduce the range of possibilities and target investigations.
2. Research is required to be undertaken at a local level in order to make accurate inferences of ethnicity. This is particularly so for multi-cultural, immigrant societies with increased admixture and complex sub-structure that is largely regionally specific.

● PHYSICAL TRAITS

Research is occurring into genetic markers linked to physical or personal traits that could be relevant for forensic purposes. The aim is to provide investigators with an inferred description of an offender, based on biological evidence recovered from a particular crime and subsequent DNA analysis. Research has predominantly focused on genetic determinants of hair, skin and eye colour.

In one of the first projects in this area researchers from the United Kingdom Forensic Science Service (FSS) described an approach to screen mutations in a gene associated with the red-hair phenotype (known as MC1R)⁵⁰. Another gene involved in the biological pathway governing human skin pigmentation is the agouti signalling protein (ASIP). Studies have shown that SNPs in the ASIP gene are associated with dark hair and brown eyes in European Americans⁵¹ and skin colour in African American females⁵².

There is also significant research being directed toward determining human eye colour. These studies indicate that SNPs significantly associated with eye colour occur in numerous genes⁵³. Therefore, no single gene could be used to make a reliable prediction about eye colour.

In addition to these forensic-specific developments, research from the genetics and medical fields describe genetic associations with physical characteristics such as stature⁵⁴ and personal traits such as a smoking habit⁵⁵.

● POTENTIAL SOCIO-LEGAL ISSUES

It is important to recognize that successful use of genetics in forensic science in the way that has been described in this section will require a paradigm shift in terms of expectations regarding the conclusiveness of the results. To date, the justice system has expressed a desire for DNA-based identifications to be as close to absolute as possible, and in the public domain, DNA identifications are often regarded as scientific certainty. Inferences drawn from predictive markers such as those described above will be less definitive and will be of most value when used as intelligence to direct police investigations, similar to an eye-witness or victim statement.

Another obvious issue associated with these developments is the switch from non-coding to associative markers. This is particularly significant in the context of debate that has occurred during the development of DNA-based legislation and databases. Opponents to expanding DNA legislation were appeased by the fact that the DNA information sought was non-diagnostic. Standard STR profiling is unable to provide any information about the race or physical appearance of the sample donor, and contribute only to the issue of identity. To further remove these concerns many jurisdictions implemented legal criteria requiring forensic agencies to destroy forensic DNA samples after analysis to ensure they would not be tested for any other genetic purpose. It is clear therefore that any perceived link between the use of phenotyping technology and DNA samples stored on State and National databases will provoke some level of controversy. However, it is not essential for the use of phenotypic markers and DNA Databases to merge, as each aims to address a different question: “What might the suspect look like?” as opposed to “Is this the suspect’s blood at the scene?” In addition, intelligence-based use of phenotypic markers does not rely upon comparison and aims instead to reduce an open-circle problem to a manageable number of possibilities. The two systems would operate best if they were used concurrently. However, departing from the non-coding basis of forensic DNA testing is significant and ensuring appropriate operational use will be fundamental to achieving a positive impact.

APPENDICES

APPENDIX I

INTERPOL STANDARD SET OF LOCI: ISSOL

Recommended INTERPOL standard set of loci (ISSOL)															
VWA		TH01		D21S11		FGA		D8S1179		D3S1358		D18S51		Amelogenin	

Additional Loci

TPOX		CSF1PO		D13S317		D7S820		D5S818		D16S539		D2S1338		D19S433	
Penta D		Penta E		FES		F13A1		F13B		SE33		CD4		GABA	

The minimum requirement for entry onto the INTERPOL DNA Database is currently any 6 of the 24 STRs

Note:

Following the recommendation by the European Network of Forensic Science Institutes (ENFSI) - the INTERPOL Standard Set of Loci (ISSOL) will be expanded in 2010 from the existing seven to twelve markers including:

*D1S1656
D2S441
D10S1248
D12S391
D22S1045*

APPENDIX 2

INTERPOL RED NOTICE

EXAMPLE John

CONTROL NO.: A-1234/11-2008

REQUESTING COUNTRY: Austria

FILE NO.: 2008/5678

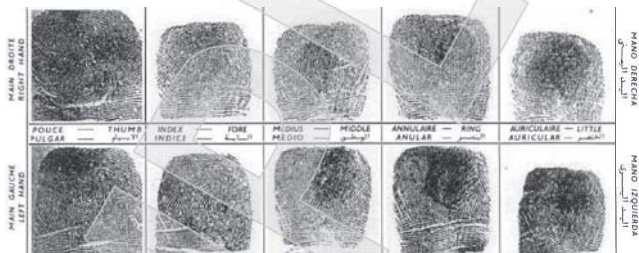
DATE OF PUBLICATION: 20 November 2008

CIRCULATION TO THE MEDIA (INCLUDING INTERNET) OF THE EXTRACTED VERSION OF THE RED NOTICE AS PUBLISHED ON INTERPOL'S PUBLIC WEBSITE: no



FUGITIVE WANTED FOR PROSECUTION

1. IDENTITY PARTICULARS



- 1.1 PRESENT FAMILY NAME: Example
- 1.2 FAMILY NAME AT BIRTH: John
- 1.3 FORENAMES: John
- 1.4 SEX: Male
- 1.5 DATE AND PLACE OF BIRTH: 7 March 1963 - Saint Petersburg, Russia
- 1.6 ALSO KNOWN AS / OTHER DATES OF BIRTH USED: EXAMPLE James
- 1.7 FATHER'S FAMILY NAME AND FORENAMES: EXAMPLE Brian.
- 1.8 MOTHER'S MAIDEN NAME AND FORENAMES: PAVLOVA Tatjana
- 1.9 IDENTITY NOT CONFIRMED
- 1.10 NATIONALITY: Russian (not confirmed)
- 1.11 IDENTITY DOCUMENTS: Russian passport no. 1234abc, issued on 15 January 2003 at the Russian Embassy in Pretoria, South Africa (expires on 14 January 2013)
- 1.12 OCCUPATION: Businessman
- 1.13 LANGUAGES SPOKEN: Russian, English, German
- 1.14 DESCRIPTION: - build: medium - height: 175 cm - weight: 85 kg - hair: brown - eyes: green
- 1.15 DISTINGUISHING MARKS AND CHARACTERISTICS:

I.16 DNA CODE:

VWA		THOI		D2ISI1		FGA		D8SI179		D3SI358		D18S51		Amelogenin	
3	4	5	6	7	8	9	10	11	12	13	14	15	15	X	Y
TPOX		CSFIP0		D13S317		D7S820		D5S818		D16S539		D2SI338		D19S433	
										16	17.1	18	19	20	21
Penta D		Penta E		FES		F13A1		F13B		SE33		CD4		GABA	

- 1.17 REGIONS/COUNTRIES LIKELY TO BE VISITED: Europe, Southern Africa
 1.18 ADDITIONAL INFORMATION: AUSTRIA: from December 2005 to July 2007, John EXAMPLE was imprisoned in South Africa for rape.

2. JUDICIAL INFORMATION

- 2.1 SUMMARY OF FACTS OF THE CASE: AUSTRIA, Vienna: on 5 October 2008, in Vienna International Airport, EXAMPLE is suspected of the rape and murder by strangulation of a female traveller.
 2.2 ACCOMPLICES: unknown
 2.3 LAW COVERING THE OFFENCE: articles 75 and 201 of the Austrian penal code
 2.4 MAXIMUM PENALTY POSSIBLE: life imprisonment
 2.5 TIME LIMIT FOR PROSECUTION OR EXPIRY DATE OF ARREST WARRANT: N/A
 2.6 ARREST WARRANT OR JUDICIAL DECISION HAVING THE SAME EFFECT: international arrest warrant, issued on 15 November 2008 by the High Court Vienna, Austria. (for member states of the European Union: European arrest warrant no.456789aa, issued on 15 November 2008 by High Court Vienna, Austria.)
 Name of signatory: Judge Dr R. SCHMID
 COPY OF ARREST WARRANT AVAILABLE AT THE GENERAL SECRETARIAT IN THE LANGUAGE USED BY THE REQUESTING COUNTRY: yes

3. ACTION TO BE TAKEN IF TRACED

- 3.1 IMMEDIATELY INFORM INTERPOL VIENNA (NCB reference: 1234567/bk/3 of 19 november 2008) AND THE ICPO-INTERPOL GENERAL SECRETARIAT THAT THE FUGITIVE HAS BEEN FOUND.
 3.2 FOR COUNTRIES WHICH CONSIDER RED NOTICES TO BE VALID REQUESTS FOR PROVISIONAL ARREST, PLEASE PROVISIONALLY ARREST THE FUGITIVE.

For countries party to the european convention on extradition, this red notice is equivalent to the request for provisional arrest referred to in article 16.

EXTRADITION WILL BE REQUESTED FROM ANY COUNTRY WITH WHICH THE REQUESTING COUNTRY IS LINKED BY A BILATERAL EXTRADITION TREATY, AN EXTRADITION CONVENTION OR BY ANY OTHER CONVENTION OR TREATY CONTAINING PROVISIONS ON EXTRADITION AND ALSO FROM THE FOLLOWING COUNTRY.

APPENDIX 3

WHAT IS FORENSIC DNA PROFILING?

BASIC DNA PRINCIPLES - THE STRUCTURE OF DNA

Nuclear DNA molecules are made up of two strands that wrap around each other in a helix to resemble a twisted ladder. The rungs of the ladder are made up of pairs of smaller molecules (monomers) called bases. There are four different bases present in DNA: adenine (A), cytosine (C), guanine (G), and thymine (T). Each base only binds with a specific complementary base - A with T and G with C. The binding of two complementary bases to form a ladder rung is called a base pair.

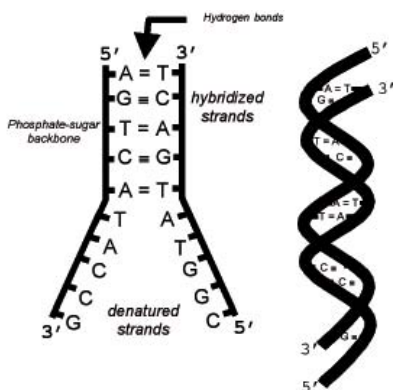


Figure 7: Structure of nuclear DNA

THE HUMAN GENOME

The human genome consists of approximately six billion base pairs along forty-six DNA molecules contained in twenty-three pairs of chromosomes in each cell nucleus. The order of bases along the DNA molecules is known as the DNA sequence.

A gene is a particular area of a DNA molecule where the sequence of bases carries information required to produce a particular protein from a particular sequence of amino acids. Proteins provide the structural units for living organisms. Genes can vary in size, but average about 3,000 base pairs in length. Human DNA contains an estimated 30,000 genes. Therefore, genetic or coding DNA makes up less than 5% of total human DNA. The remainder of the DNA is non-coding DNA.

Some areas of non-coding DNA are consistent across all people, while other areas vary significantly between individuals. It is this variability that provides the basis for distinguishing between individuals through DNA profiling.

THE PROCESS OF DNA ANALYSIS

The biological material that is to be tested (blood, semen, saliva, etc) needs to be delivered in a suitable form to the laboratory. This may involve swabbing of large items and analyzing the swab, cutting a stain from an item of clothing, or using adhesive tape to remove skin cells from an item that a person has touched.

Extraction

DNA is extracted from the cells by removing all of the proteins, membranes and other cellular material that can be present in a biological sample. There are different principles that are applicable: one of them is the affinity of DNA to membrane silica that allows for binding and releasing DNA, therefore, making the removal of residual cell components possible. Another principle makes use of the water solubility that separates DNA from the lipophilic cellular elements. In an ideal world the pure extracted DNA is re-suspended in a buffer or bi-distilled water and ready for DNA typing.

Quantitation

DNA quantitation is an important step in the analysis. Here, the amount of extracted DNA obtained from the cells is determined. The concentration of extracted DNA varies strongly depending on the nature and size of the investigated tissue and usually ranges between zero and some hundred nanograms (ng). The sensitivity of downstream genotyping applications is around 20 cells (approx. 130pg DNA) under standard laboratory conditions.

Amplification

This stage increases or amplifies, the very small amount of DNA that is present in forensic samples to an amount that will allow a DNA profile to be detected. PCR does this by splitting each DNA molecule (double-stranded) into two pieces and using the two single strands as a template for new DNA molecules. The missing half of the DNA helix is rebuilt on to each of the two original pieces. This results in two complete DNA molecules, each identical to the first. The whole doubling process is performed over again, twenty-five to thirty-five times in a row, ideally doubling the total number of DNA molecules present at each stage. This results in a final number of DNA molecules several million times higher than the original starting number. In this way, PCR amplification can turn tiny amounts of DNA into an amount large enough to create a DNA profile. For human identification so-called Short Tandem Repeats (STR) became the markers of choice as they display a great variance of alleles in a given population. Therefore they can be used to effectively discriminate between unrelated individuals. Today more than 10 unlinked STR markers are co-amplified in a single multiplex PCR that results in a so-called STR-profile, statistically discriminating well beyond one individual in a billion.

Electrophoresis

Electrophoresis is a method designed to separate DNA fragments differing in size. A multiplex PCR-amplified STR-profile contains multiple STR fragments that have different fragment lengths depending on the individual alleles. Through electrophoresis

they get sorted by size and displayed in an electropherogram (EPG). The electrophoresis step takes the amplified DNA produced after the PCR stage and separates the different DNA fragments that it contains based on their size. This allows the size of the fragments to be measured and from this information an STR-based DNA profile can be obtained.

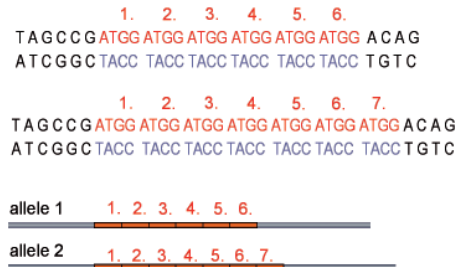


Figure 8: Structure of STRs (TH01)

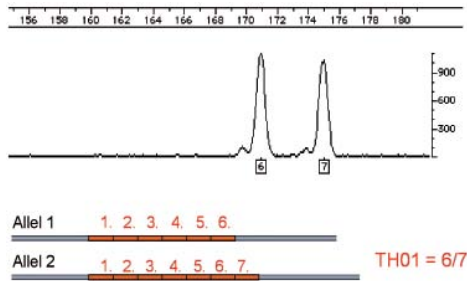


Figure 9: Electrophoresis of STRs (TH01)

A DNA profile is a computerized alpha-numeric value obtained from the electropherogram. An example of such a DNA-profile investigating eight STR loci is shown below:

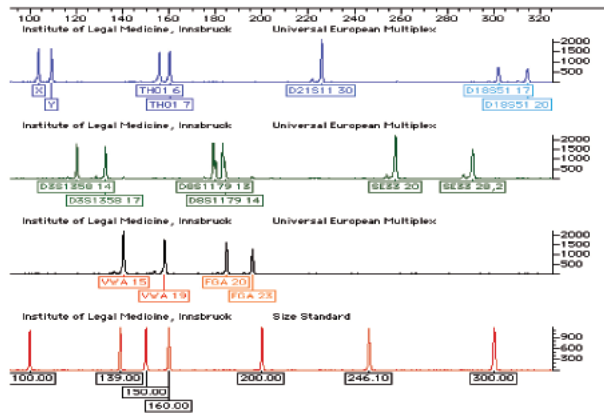


Figure 10: Electropherogram of eight STR loci

Analysis

The data generated by electrophoresis is used to measure the size of the DNA fragments in a sample. From this, the number of STR repeat units that a person has at each locus is determined. This results in the creation of an STR-profile that is characteristic for the person. It is not necessarily unique. Identical twins share the same STR-profile. It is further possible that two unrelated people share the same profile, which is a very rare phenomenon, however, that can be statistically well defined. The statistical evaluation is part of the expert report and will be presented by court.

HISTORY OF DNA PROFILING METHODS

Restriction Fragment Length Polymorphism (RFLP)

The first technique applied in forensics was the analysis of restriction fragment length polymorphisms. DNA is extracted from samples and cut by a sequence-specific enzyme (the so called restriction enzyme) before being separated by electrophoresis on an agarose gel on the basis of molecular weight. After being transferred by capillary action (blot technique) to a nylon membrane the polymorphic mini-satellite regions of the DNA are then examined by the addition of radioactively labelled pieces of a single stranded DNA - called probes. A probe binds to its complementary sequence on the membrane, allowing it to be seen and compared with standards when the membrane is exposed to x-ray film.

Multi Locus Profiling (MLP)

The probes used in the early days of forensic DNA profiling involved the simultaneous analysis of mini-satellite regions of the DNA and were called Multi Locus Probes resulting in Multi Locus Profiles (MLP). This method of analysis required relatively large amounts of DNA, however (up to two micrograms). The interpretation of results from samples containing only a low amount of DNA, or from mixed samples was difficult and very often impossible. Thus, only selected cases were suitable to be investigated using this method. MLP was superseded in the early 1990s by Single Locus Profiling (SLP) which looked into one defined spot of the human genome only.

Single Locus Profiling (SLP)

Different to the MLP analysis, where several regions of the DNA are examined in parallel within one process resulting in powerful information, a SL analysis can only contain the information of a single locus. The frequency of each DNA fragment detected is estimated from a population database. To enhance the power of discrimination (in other words: to enhance the probability that a person that has the same profile as a crime scene stain really is the source of the stain), the process has to be repeated using probes for additional loci. In contrast to MLP, the SLP method can be used to resolve mixed samples, and the analysis can be carried out using less DNA (typically 0.5-1 microgram), allowing for testing of smaller samples. However, one microgram is still a

lot of DNA as compared with the amount required for modern forensic techniques.

Polymerase Chain Reaction (PCR)

The crucial step into today's technologies was the Polymerase Chain Reaction (PCR). PCR takes advantage of the ability of DNA to replicate itself. The method exponentially copies, or amplifies, specific parts of a DNA molecule, resulting in a solution that contains many thousands of identical copies of the original molecule. This allows analysis of much smaller samples than is otherwise possible. The first commercial kit widely used in the forensic field investigated the HLA DQA1 locus. The so called dot blot technique that came along with that kit was obviously easy to apply, but in fact required a lot of experience, and did not allow the investigation of mixtures in general.

Short Tandem Repeat (STR)

The short tandem repeat, or STR, profiling is a method which uses the PCR technique to target short sequences of DNA. Using gel electrophoresis at the beginning of that era, and now mostly capillary electrophoresis, many loci can be investigated in parallel. The commercial kits applied worldwide look into a panel of 11 to 16 loci. To obtain reliable results as little as 10-20 picograms of DNA (one picogram is equal to one thousand billionth of a gram) are needed. Mixtures can easily be identified as such, as the profile will consist of more than the two alleles per locus which are expected from one person (homozygosity and common alleles may result in less than two or four alleles respectively). Multiplex analysis of autosomal STRs has turned out to be the standard technique worldwide. Contributing to that tremendous development are the statistics, which are extremely powerful for a full profile, and even in case of a mixture still essential in court. To handle the large amount of samples, automation, laboratory information management systems (LIMS), and expert systems for allele designation are applied.

COMMERCIAL AVAILABLE KITS

A choice of kits is available for STR analysis used in forensics. The two primary vendors are the Promega Corporation located in Madison, Wisconsin, and Applied Biosystems located in Foster City, California. These companies have expended a great deal of effort over the past decade to bring STR markers to forensic scientists in kit form. More recently in Europe, companies such as Serac (Bad Homburg, Germany) and Biotype (Dresden, Germany) have begun to offer commercial STR kits. A list of commercially available STR multiplexes and when they were released as products is shown in the table below.

Table 6: Commercially available STR kits – chronological overview

Name	Source	Release Date	STR Loci included				
TH01, TPOX, CSFIPO monoplexes (silver stain)	Promega	Feb 1993	TH01	TPOX	CSFIPO		
AmpF/STR Blue	Applied Biosystems	Oct 1996	D3S1358	VWA	FGA		
AmpF/STR Green I	Applied Biosystems	Jan 1997	Amelogenin	TH01	TPOX	CSFIPO	
CTTv	Promega	Jan 1997	CSFIPO	TPOX	TH01	VWA	
FFFL	Promega	Jan 1997	F13A1	FES/ESP	F13B	LPL	
GammaSTR	Promega	Jan 1997	D16S593	D13S317	D7S820	D5S818	
PowerPlex (version 1.1 and 1.2 later)	Promega	Jan 1997	CSFIPO	TPOX	TH01	VWA	D16S593
		Sep 1997	D13S317	D7S820	D5S818		
AmpF/STR Profiler	Applied Biosystems	May 1997	D3S1358	VWA	FGA	Amelogenin	TH01
			TPOX	CSFIPO	D5S818	D13S317	D7S820
AmpF/STR Profiler Plus	Applied Biosystems	Dec 1997	D3S1358	VWA	FGA	Amelogenin	D8S1179
			D21S11	D18S51	D5S818	D13S317	D7S820
AmpF/STR Cofiler	Applied Biosystems	May 1998	D3S1358	D16S539	Amelogenin	TH01	TPOX
			CSFIPO	D7S820			
AmpF/STR SGM Plus	Applied Biosystems	Feb 1999	D3S1358	VWA	D16S539	D2S1338	Amelogenin
			D8S1179	D21S11	D18S51	D19S433	TH01
			FGA				
PowerPlex 2.1 (for Hitachi FMBIO users)	Promega	Jun 1999	D3S1358	TH01	D21S11	D18S51	VWA
			D8S1179	TPOX	FGA	Penta E	
PowerPlex 16	Promega	May 2000	CSFIPO	FGA	TPOX	TH01	VWA
			D3S1358	D5S818	D7S820	D8S1179	D13S317
			D16S539	D18S51	D21S11	Penta D	Penta E
			Amelogenin				
PowerPlex 16 BIO (for Hitachi FMBIO users)	Promega	May 2001	CSFIPO	FGA	TPOX	TH01	VWA
			D3S1358	D5S818	D7S820	D8S1179	D13S317
			D16S539	D18S51	D21S11	Penta D	Penta E
			Amelogenin				

Name	Source	Release Date	STR Loci included				
AmpF/STR Identifier	Applied Biosystems	Jul 2001	CSFIPO	FGA	TPOX	TH01	VWA
			D3S1358	D5S818	D7S820	D8S1179	D13S317
			D16S539	D18S51	D21S11	D2S1338	D19S433
			Amelogenin				
AmpF/STR Profiler Plus ID	Applied Biosystems	Sep 2001	D3S1358	VWA	FGA	Amelogenin	D8S1179
			D21S11	D18S51	D5S818	D13S317	D7S820
PowerPlex ES	Promega	Mar 2002	FGA	TH01	VWA	D3S1358	D8S1179
			D18S51	D21S11	SE33	Amelogenin	
AmpF/STR Sefiler	Applied Biosystems	Sep 2002	FGA	TH01	VWA	D3S1358	D8S1179
			D16S539	D18S51	D21S11	D2S1338	D19S433
			SE33	Amelogenin			

Table 7: example of a DNA profile in compliance with international standards

VWA		TH01		D21S11		FGA		D8S1179		D3S1358		D18S51		Amelogenin	
17	18	6	8	29	31.2	22	26	14	15	17	17	14	15	X	Y
TPOX		CSFIPO		D13S317		D7S820		D5S818		D16S539		D2S1338		D19S433	
				11	13	8	11	11	12						
Penta D		Penta E		FES		F13A1		F13B		SE33		CD4		GABA	
										28	28.2	10	10		

APPENDIX 4

QUESTIONS AROUND AN INTELLIGENCE-LED SCREEN (ILS)

Whatever you are doing with the DNA evidence, it should always be considered together with other physical evidence in the case (fingerprints, tool marks, and so forth).

Investigators Consideration Checklist:

The following list is not comprehensive as each case will be unique and will require its own specific approach. This checklist aims to act as a guideline. When considering any aspect of the investigation, the investigator should ensure that what they propose is in accordance with the law and a proportionate and non-discriminatory means of achieving a legitimate aim.

- Is the crime likely to yield a DNA profile from the offender?
- Is the obtained DNA profile attributable to the offender?
- Is it a full profile or a partial profile?
- If a full profile, is it likely that the enquiry will at some stage become a mass screen?
- If a partial profile, do not disregard the value of DNA being able to eliminate suspects.
- If a full profile - is a mass screen the best way to commence the enquiry or will a limited screen of a number of subjects with prominence within the investigation, be an initial alternative?
- Have you contacted your forensic provider to ensure a mass screen is possible and can be put in place?
- Are you sure that the profile has been checked against other crime scenes?
- Have you contacted a specialist advisor for help and assistance? Also consider other investigators with recent experience of a similar enquiry.
- Have you considered using a Behavioural Investigative Advisor?
- Have you considered using a Geographical Profiler?
- Have you considered using Serious Crimes Analysis?
- Have you considered further scientific work to give any indication of the suspect's ethnic origin? It may also be possible to get a prediction of hair colour and eye colour.
- Have you considered a familial search of the database?
- Have you considered Tactical Swabbing, for example taking DNA from other family members if the suspect is not available?

- Have you considered an INTERPOL bulletin?
- If you do a mass screen, have you put out a media statement as to why you will be doing a mass screen?
- Have you considered the likely effect on the suspect of such a media announcement?
- If a mass screen - have you identified the staff with knowledge to set it up?
- Have you identified the staff and resources necessary to put a mass screen in place?
- Have you considered that if the screen goes on for some time there may come a time when a lot of pressure will be put on you to return these staff to other policing demands?
- Are you satisfied that the house to house or whatever other means employed has identified all of the persons living and/or working in the area?
- Have you considered persons living outside the area who only occasionally visit to work or socialize?
- Are you satisfied that the suspect Scoring Matrix is correct and flexible?
- Have you considered that the offender may be recorded as having a DNA profile, but it is not loaded to the DNA Database?
- Have you considered that the suspect may have committed other offences in other countries?
- Have you considered that the offender may be on a DNA Database in another country?
- Have you put in place an effective communication system between the enquiry and the National DNA Database, for instance e-mails, fax, and 24hr nominated police Forensic Liaison Officer?
- Have you ensured that a policy is in place to regularly review persons of interest who have previously been researched and scored below the matrix threshold but may later score above it due to the parameters having been changed or new intelligence on the subject?
- Have you put in place a robust and reliable Refusals Policy?
- Have you put in place a Death Policy?
- Have you made up a list of FAQs and their answers for the swabbing teams?
- Have you addressed the training issues required for staff?
- Does everyone involved know their roles and responsibilities, i.e. job descriptions?
- Have you considered taking DNA from other members of the charged person's family to negate any familial defence that may be raised at trial?
- Have you ensured that you and all others on the enquiry realize that this is an investigation that is best brought to fruition by teamwork involving Major Crime Teams, CID, Uniform, forensic provider, media, public, etc?

APPENDIX 5

DNA FACT SHEET



INTERPOL

DNA Profiling

Deoxyribonucleic acid (DNA) molecules contain the information all living cells in the human body need to function. They also control the inheritance of characteristics from parents to offspring. With the exception of identical twins, each person's DNA is unique, which makes DNA sampling useful for solving crimes, identifying victims of disasters, and locating missing persons.

DNA's role in solving crimes

DNA profiling can play a crucial role in solving crimes, as it has the potential to link a series of crimes and/or to place a suspect at the scene of a crime. Just as importantly, DNA can help to prove a suspect's innocence.

The first step in obtaining DNA profiles for comparison is the collection of samples from crime scenes and reference samples from suspects. Samples are commonly obtained from blood, hair or body fluids. Advances in DNA technology enable samples to be obtained from decreasingly smaller traces of DNA found at crime scenes. Using forensic science methods, the sample is analysed, resulting in a DNA profile that can be compared against other DNA profiles within a database. This creates the opportunity for 'hits' – scene-to-scene, person-to-scene or person-to-person matches – where no previous connection was known.

INTERPOL's DNA database

Police in member countries can submit a DNA profile from offenders, crime scenes, missing persons and unidentified bodies to INTERPOL's automated DNA database. Known as the DNA Gateway, the database was created in 2002 with a single DNA profile but, as of the end of 2008, it contained more than 82,000 DNA profiles contributed by 48 member countries. Participating countries are actively using the DNA Gateway as a tool in their criminal investigations, and it regularly detects potential links between DNA profiles submitted by member countries – searches of the database by member countries led to 27 international hits during 2008.

Member countries can access the database via the organization's I-24/7 global police communications system and, upon request, access can be extended beyond the member countries' National Central Bureaus to forensic centres and laboratories.

INTERPOL serves only as the conduit for the sharing and comparison of information. It does not keep any nominal data linking a DNA profile to any individual. A DNA profile is simply a list of numbers based on the pattern of an individual's DNA, producing a numerical code which can be used to differentiate individuals. This profile does not contain information about a person's physical or psychological characteristics, diseases or predisposition for diseases. Member countries that use the DNA Gateway retain ownership of their profile data and control its submission, access by other countries and destruction in accordance with their national laws.

FACT SHEET **COM/FS/2009-08/FS-01**



Promoting standards, ethics and best practice

INTERPOL advocates international technical standards and systems in order to enhance the opportunities for successful cross-border collaboration. For example:

- The DNA Gateway is developed to its internationally recognized standard to facilitate the electronic transfer of DNA data between INTERPOL and its member countries.
- The Gateway is also compatible with the EU Prüm convention (a 2005 initiative to simplify data exchange in the EU countries), and for selected international export of DNA profiles for countries using CODIS (the FBI-designed DNA matching software).
- The G8 DNA Search Request Network uses INTERPOL's I-24/7 system and DNA standards to communicate profiles among G8 countries.

In addition to the DNA Gateway, INTERPOL strongly supports the increased use of DNA profiling in international police investigations through two other main areas of activity:

- The Monitoring Expert Group is a panel of forensic experts and senior investigators which advises INTERPOL and encourages authorities in member countries to implement or expand national DNA databases. It also works to standardize collection efforts and to promote accreditation criteria for forensic laboratories to ensure the integrity of samples.
- A DNA Users' Conference for investigative officers, held every two years, examines developments in DNA applications and encourages the widespread use of best practice and DNA technology in criminal investigations.



www.interpol.int

Contact information

E-mail: info@interpol.int

For matters relating to specific crime cases, please contact your local police or the INTERPOL National Central Bureau in your country.

APPENDIX 6

INTERPOL DNA SEARCH REQUEST FORM

INTERPOL DNA PROFILE SEARCH REQUEST

REQUEST			
FROM NCB:		NCB REFERENCE:	
TO NCB:		REQUEST DATE:	
NATIONAL AGENCY REQUESTING SEARCH:		COPY NCB:	
		AGENCY REFERENCE:	
EMAIL ADDRESS/PHONE/FAX NUMBER:			

OFFENCE	
CATEGORY:	
PLACE:	DATE OF OFFENCE:
ADDITIONAL INFORMATION:	

DNA PROFILE INFORMATION											
NATIONAL DNA PROFILE REFERENCE:											
SUSPECT ☐				CONVICTED ☐				CRIME STAIN ☐			
MISSING PERSON ☐				UNIDENTIFIED BODY ☐				OTHER ☐			
VWA	TH01	D21S11	FGA	D8S1179	D3S1358	D18S51	Amelogenin				
TPOX	CSF1P0	DI3S317	D7S820	D5S818	DI6S539	D2S1338	DI9S433				
Penta D	Penta E	FES	FI3A1	FI3B	SE33	CD4	GABA				
OTHER LOCI											
THIS PROFILE HAS BEEN PRODUCED IN AN ACCREDITED LABORATORY: YES ☐ NO ☐											

IN CASE OF A NEGATIVE SEARCH			
STORE THIS PROFILE	YES ☐	IF YES, UNTIL WHEN:	NO ☐
SEARCH THIS PROFILE AGAIN	YES ☐	IF YES, HOW OFTEN:	NO ☐

REPLY			
FROM NCB:	NCB REFERENCE:	REPLY DATE:	
TO NCB:		COPY NCB:	

THE FOLLOWING RESULT HAS BEEN OBTAINED AFTER THE SEARCH:	
POTENTIAL MATCH ☐	NO MATCH ☐

DNA PROFILE MATCHED TO:		
SUSPECT ☐	CONVICTED ☐	CRIME STAIN ☐
MISSING PERSON ☐	UNIDENTIFIED BODY ☐	OTHER ☐

PROFILE RETENTION:			
PROFILE STORED	YES ☐	IF YES, UNTIL WHEN:	NO ☐
PROFILE WILL BE SEARCHED AGAIN	YES ☐	IF YES, HOW OFTEN:	NO ☐

THE FOLLOWING MATCH OCCURRED:											
MATCH REPORT NUMBER:											
NCB REFERENCE:						SAMPLE REFERENCE:					
VWA	TH01	D21S11	FGA	D8S1179	D3S1358	D18S51	Amelogenin				
TPOX	CSF1P0	D13S317	D7S820	D5S818	D16S539	D2S1338	D19S433				
Penta D	Penta E	FES	FI3A1	FI3B	SE33	CD4	GABA				
OTHER LOCI											
ADDITIONAL INFORMATION:											

Disclaimer: no responsibility can be taken by INTERPOL for the accuracy or quality of the information provided INTERPOL DNA Profile Search Request Form. Version 2, 2009

APPENDIX 7

RECOMMENDATIONS

FROM THE ENFSI WORKING GROUP

List of the recommendations from the document as per April 2008:

1. Every EU/ENFSI-country should establish a forensic DNA-database and specific legislation for its implementation and management.
2. The type of crime-related stain DNA-profiles which can be included in a DNA-database should not be restricted.
3. To increase the chance of a DNA-profile of a stain to match to a person, the number of persons which are likely to cause matches in a DNA-database should be as high as legally (and financially) possible.
4. Managers of national DNA-databases should establish (together with other stakeholders) criteria for the inclusion of partial DNA-profiles to obtain an acceptable balance between the minimum allowable level of evidential value (match probability) of a DNA-profile and maximum number of adventitious matches a partial DNA-profile is expected to generate.
5. DNA-profiles produced by older commercial kits should be upgraded (if possible) after a match in the national DNA-database to increase the evidential value of the match and also to fulfil the criteria for international comparison if a country wants to include DNA-profiles produced by older commercial kits in international search actions.
6. The number of loci in reference samples should be the maximum of the number of loci present in the kit(s) used for the production of the DNA-profiles of the reference samples to enhance the chance of finding relevant matches with partial DNA-profiles.
7. Labs producing DNA-profiles for a DNA-database should, as a minimum, be ISO-17025 (and/or equivalently nationally) accredited and should participate in challenging proficiency tests (for Europe: GEDNAP).
8. When low copy number DNA-profiles are included in a DNA-database a dedicated (near) match strategy should be used for them.
9. When a new allele is observed in a DNA-profile, its presence should be confirmed by repeated DNA-isolation, PCR, Capillary Electrophoresis and allele calling of the DNA-profile.

10. Alleles from loci with chromosomal anomalies should not be included in a DNA-database as they may be caused by somatic mutations which may only occur in certain tissues/body fluids.
11. Wild cards which do not represent a designated allele should not be part of the minimum number of loci/alleles required for a match.
12. The guidelines in the document of the ISFG-working group on the analysis of mixed profiles should be used for the analysis of mixed profiles.
13. A numerical match between a reference sample and a mixed profile must always be checked against the plot of the mixed profile.
14. Mixed profiles of more than two persons should not be included in a DNA-database because they cause too many adventitious matches.
15. If the removal of a DNA-profile from the DNA-database is dependent on external information, a process should be in place to give the custodian of the DNA-database access to this information, preferably by means of an automated message to him after an event which influences the deletion date of a DNA-profile.
16. There should be a system which can be consulted by those responsible for sampling persons to see whether a person is already present in the DNA-database.
17. The system which can be consulted by those responsible for sampling persons to see whether a person is already present in the DNA-database should be combined with a rapid biometric identification system like fingerprints to verify whether a person is already present in the DNA-database.
18. Any DNA-database should have an associated elimination DNA-database (or databases) including anybody working on the DNA-samples in the DNA-lab but also people cleaning the labs or performing any other kind of maintenance. Also people earlier in the chain of custody like the police and other persons present at the scene of crime should be included as well as unidentified DNA-profiles found in negative control samples which may come from people involved in manufacturing disposables and/or chemicals. The latter type of DNA-profiles should be shared with other ENFSI-countries.
19. The occurrence of errors in DNA-profiles as a result of human mistakes associated with data entry should be avoided as much as possible by automating the allele calling and the DNA-database import process. When DNA-profiles are entered manually into the DNA-database this should be done by a process which detects typing errors, for example by double (blind) entry of data.
20. When a DNA-database for historical reasons may contain DNA-profiles with typing and/or allele-calling errors or null alleles, regular searches allowing one or more mismatches may be performed but the pro's and con's of this strategy should be evaluated in advance.

21. As a national DNA-database regularly is subject to attention from the public, politicians and the media, a DNA-database manager should consider establishing performance parameters and making these publicly available.
22. DNA-database managers should be aware of the possibility of adventitious matches and be able to calculate their expected numbers for the matches they report. When this chance is too high as compared to a nationally set standard, the DNA-database manager should include a recommendation in his/her match report to determine more loci to increase the match probability of the DNA-profile or to find additional other non-DNA-evidence.
23. A DNA-database match report of a crime scene related DNA-profile with a person should be informative and may contain an indication of the evidential value of the match and/or a statement that the match should not be used as evidence without additional evidence indicating the involvement of the person.
24. DNA profiles should be entered into a database in a way that guarantees their correct import:
 - Access to the DNA-database should be dictated by limited physical and organizational measures to those persons who need to have access.
 - Regular backups should be made, stored in a safe place, and put back at regular intervals to simulate recovery from a disaster.
 - When DNA-profiles and their associated information are present in different systems, these systems should be regularly compared to check whether they are still properly synchronized.
25. Information from a national DNA-database should be combined with other types of evidence to increase the number of crimes for which a suspect can be identified and to increase the number of suspects which can be identified.
26. As automated processes reduce the possibility of human errors, they should be introduced for those processes that are straightforward.
27. DNA-database matches with mixed and partial profiles should always be checked by a DNA-specialist to determine whether the numerical match could be a real match.
28. From a forensic point of view the cell material of reference samples should be stored.
29. Because DNA-databases have a very important but also very delicate role in society, the custodian of a DNA-database should develop tools to make objective information about the DNA-database available to politicians, the public and the media.

The list is available at www.enfsi.eu > expert working groups > DNA.

GLOSSARY AND ABBREVIATIONS

I-24/7	INTERPOL's I-24/7 global police communications system connects law enforcement officials in all of its 187 member countries, providing them with the means to share crucial information on criminals and criminal activities 24 hours a day, seven days a week.
Allele	Alternative form of the same DNA section at a specific location (locus) on a chromosome. A single allele for each locus is inherited separately from each parent.
Amelogenin	The name of a gene which indicates the gender (i.e. sex) of the individual.
Biological evidence	Evidence derived from biological material, typically body fluids associated with serious crimes.
Blood device	Sterile devices (tubes, containers or other items) used for the recovery of biological samples from individuals and crime scenes.
Breathable bag	Plastic or paper bag which allows moisture to pass through the bag thereby enabling damp/wet samples to dry out within the bag without deteriorating/degrading.
Cold hit	A match made in a database not based on investigative leads.
Contamination	The accidental pollution of a crime scene and/or sample with other biological or chemical substances. This may occur as a result of touching, sneezing, speaking over the crime stain/sample, and so forth.
Control sample	A standard against which other conditions can be compared. For example, an area adjacent to a crime stain to allow for problems with equipment to be detected.
Crime scene stain	A biological sample that is found at the scene of a crime. DNA analysis is conducted to establish an association between the crime scene and an individual.
DNA	Deoxyribonucleic Acid is a molecule found in most cells of all people, animals, plants and other organisms. Variations in the DNA sequence enable the distinction between individuals.
DNA profile	A set of DNA identification characteristics at numerous specific DNA locations (loci) that can be used to distinguish one person from that of another person.

Elimination Sample	A DNA sample provided with consent by an individual to exclude them as possible suspects or by a person whose DNA may have contaminated a sample.
Epithelial cells	The outside layer of cells that covers the internal and external body organs including skin and mucous membranes.
Fingerprints	A fingerprint is a deposit of fatty residue left behind after a finger touches a surface and the sweat evaporates. The pattern left behind is unique to an individual and can be used to identify and link evidence in a similar way to DNA.
Gene	The basic unit of heredity that contains the genetic information contained in the DNA of an organism.
Genetic information	The DNA code sequence which contains an individual's traits.
Genome	The total genetic material of an organism. In humans, there are two genomes: chromosomal and mitochondrial.
Genotype	The genetic constitution (genome) of an individual.
Haploid regions	Genetic regions that exist in singular form, such as the human Y-chromosome, or mitochondrial DNA genome. The genetic content of sex cells (or gametes) is also haploid as there is only one copy of each chromosome.
Hit/Match	When there are sufficient similarities between two DNA profiles in a database for them to be considered a match. The terms 'match' and 'hit' are synonymous. For the purposes of this document this term is interchangeable.
Intelligence led DNA screening/Mass screen	If the police suspect that the person who committed the crime lives in a particular village or works at a particular place, they can request everyone in that village or workplace to give a reference sample. The samples are collected on a voluntary basis. The main aim is to eliminate individuals from the enquiry and the samples obtained should only be compared with evidence related to the investigation in question.
INTERPOL Standard Set Of Loci (ISSOL)	This is the standard set of loci that INTERPOL recommends for easier international comparison.
Locus (pl. loci)	The physical location of a gene (or DNA region of interest) on a chromosome.
Low Copy Number (LCN)	A very sensitive DNA system designed to obtain a DNA profile from very small amounts of DNA. It is mostly used in high-profile, serious crime cases where conventional DNA systems have failed to give a profiling result.

Member Countries	INTERPOL has 188 countries that are a member of its organization and work with and benefit from all that INTERPOL has to offer.
Mitochondrial DNA (mtDNA)	Mitochondrial DNA is found in the mitochondria of the cell and is associated with the energy production function of the cell. Its analysis is very different from that of the DNA found in the cell nucleus and mitochondrial DNA profiles are not compatible with the DNA profiles on the NDNAD. Mitochondrial DNA profiles are less discriminating than STR profiles (SGM/SGM+) but are useful when STR profiles cannot be obtained.
Mutation	A change in the characteristics of an organism arising from a change in the genes of the organism ⁵⁷ .
Non-autosomal	An autosome is a chromosome that has no role in sex determination. In humans this is the 22 chromosomes that are not the sex chromosomes (X or Y). Regions of DNA that are not on autosomes are referred to as “non-autosomal”. This may be because they exist on the X or Y chromosomes, or, for example, on the mitochondrial DNA genome.
Non-coding region	Non-coding DNA represents 99% of the human genome and contains certain differences in DNA sequence (polymorphisms) that are inherited, but do not influence an individual's physical characteristics and; therefore, provide no information of significance, for example about an individual's predisposition to a particular medical condition ⁵⁸ .
Phenotypes	The observable characteristics of an individual organism; the consequence of the underlying genotype and its interaction with the environment ⁵⁸ .
Physical evidence	Typically this describes physical matter that can hold evidential significance. This can be matter such as paint, glass, fibres etc.
Polymerase Chain Reaction (PCR)	A rapid, inexpensive and simple chemical reaction used to increase the quantity of DNA evidence present. However, the presence of contaminants and multiple samples will render this technique ineffective.
Polymorphisms	Variations in the genome at a given location. Originally applied to alleles producing new phenotypes ⁵⁷ .
Random Match Probability (RMP)	A statistical statement that indicates the significance or strength of the match of two DNA profiles. The larger the number in the frequency estimate, the rarer the profile and therefore the more significant the results. The RMP does not indicate the probability of the suspect being guilty and great care should be taken not to convey this impression.

Reference sample	A DNA profile obtained from a known individual. These may include, suspects, offenders, and convicted individuals.
Restriction Fragment Length Polymorphism (RFLP)	An older method of forensic DNA analysis based on the different sized fragments that can be produced when a piece of DNA is cut by certain enzymes. Replaced by STR analysis due to the large amount of DNA required for it to work, as well as the long time needed for analysis.
Short Tandem Repeats (STRs)	The current method of DNA profiling is known as profiling Short Tandem Repeats (STR profiling). This technique looks at specific short lengths of the DNA. These short pieces are repeated, end-to-end, within the DNA molecule. Different people will have different numbers of repeats of these pieces and hence different lengths of this repeated DNA. The STR profiling technique examines the length of these repeat units and converts the length into a numerical output.
Single Nucleotide Polymorphisms (SNPs)	Polymorphic regions of the DNA that involve a single base change only.
Tamper evident bag	Plastic bag which, once sealed, will indicate if the seal has been interfered with in any way.
Telogenic hairs	Hairs that are shed naturally.
Y - chromosomes	The male determining chromosome. DNA markers on this chromosome are used more commonly now in sexual assault examinations.

ABBREVIATIONS

AIMS	Ancestry Informative Markers
ASCLD/LAB	American Society of Crime Laboratory Directors-Laboratory Accreditation Board
ASIP	Agouti Signalling Protein
BELTEST	Accreditation System for test laboratories and inspection bodies (Belgium)
CCTV	Closed Circuit Television
CID	Criminal Investigation Department
CSI	Crime Scene Investigation
DNA	Deoxyribonucleic Acid
EDNAP	European DNA Profiling group
ENSFI	European Network of Forensic Science Institutes
FSS	Forensic Science Service (United Kingdom)
ILAC	International Laboratory Accreditation Co-operation (United Kingdom)
IPSG	INTERPOL General Secretariat
ISO	International Organization for Standardization
ISSOL	INTERPOL Standard Set Of Loci
LCN	Low Copy Number
MC1R	Melanocortin 1 Receptor
MEG	Monitoring Expert Group
MTDNA	Mitochondrial DNA
NATA	National Association of Testing Authorities (Australia)
NCB	National Central Bureau (INTERPOL)
NFSTC	National Forensic Science and Training Centre (United States)
PCR	Polymerase Chain Reaction
QA	Quality Assurance
RMP	Random Match Probability
SANAS	South African National Accreditation System
SIO	Senior Investigating Officer
SNPS	Single Nucleotide Polymorphisms
SOP	Standard Operating Procedure
SRN	Search Request Network
STRS	Short Tandem Repeats
SWEDAC	Swedish Board for Accreditation and Conformity Assessment
UKAS	United Kingdom Accreditation Service
UV	Ultraviolet
VIA	Vienna International Airport
Y-STRS	Y-chromosome Short Tandem Repeats

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Picture 1 – Vienna International Airport	15
Source: Bundespolizeidirektion Schwechat Kriminalpolizeiliche Abteilung Referat für Kapitalverbrechen, Betrug, Falschgeld, Umweldelikte, Brand- u. Explosionsursachenermittlung, Flugunfälle A-2320 Schwechat, Wiener Straße 13 Tel.: +43/ (0)1/701 50 – 2700, Fax: +43/ (0)1/701 50 – 2709	
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Source: Bundespolizeidirektion Schwechat Kriminalpolizeiliche Abteilung	
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Source: Bundespolizeidirektion Schwechat Kriminalpolizeiliche Abteilung	
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