Scottish Biometrics Commissioner

Leverhulme Research Centre for Forensic Science University of Dundee

SCOTTISH POLICE AUTHORITY
ÙGHDARRAS POILIS NA H-ALBA

Joint Assurance Review

of the acquisition, retention, use and destruction of DNA for criminal justice and police purposes in Scotland

Safeguarding our biometric future

Scottish Biometrics Commissioner
Coimiseanair Biometrics na h-Alba

Contents

Produced and published by the Scottish Biometrics Commissioner under the provisions of Sections 2 and 3 of the Scottish Biometrics Commissioners Act 2020 – SBC/2025/01. Laid before the Scottish Parliament by the Commissioner in February 2025 under Section 20(2) of the Act.

www.biometricscommissioner.scot

Key facts

DNA interpretation and analysis is scientifically robust and with fingerprints leads the biometric technologies used in world policing. However, there is no such thing as a biometric technology which is 100% accurate all the time.

The cost for SPA Forensic Services to produce a simple DNA profile is £32, whereas a complex sample requiring scientist interpretation is around £79. The annual cost of providing all DNA interpretation and analysis capabilities including consumables is around £2.1 million.

SPA Forensic Services are the largest public sector provider of forensic services in Europe, providing world class, not for profit forensic services in Scotland.

Using DNA24, SPA Forensic Services provide Police Scotland and other criminal justice partners in Scotland with access to the most advanced DNA interpretation and analysis capability currently available in world policing. It is of a higher standards than used elsewhere in the UK and above Interpol standard.

DNA is not used routinely in most police investigations in Scotland and most crimes reported to the police are not the subject of a forensic crime scene examination or DNA recovery.

Police Scotland and SPA Forensic Services retain the DNA of convicted persons until their 100th birthday or 3 years after death, whichever is sooner. This policy is not proportionate and is currently under review following recommendations made jointly by the Commissioner and Scottish Government to Police Scotland in October 2024.

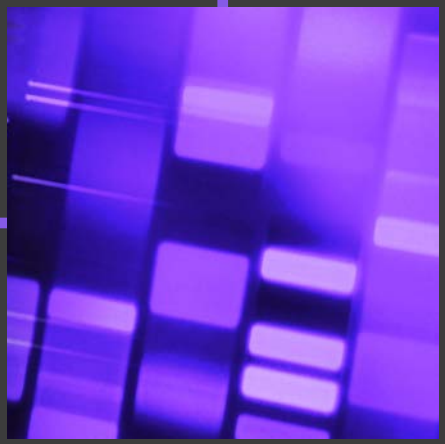
The scientific methods deployed by SPA Forensic Services in relation to DNA are independently validated and accredited to international scientific standard ISO/IEC 17025:2017 by the United Kingdom Accreditation Service (UKAS).

DNA has an important exculpatory (elimination) value which although significant this data is not collated and therefore does not feature in any official statistics.

On 31 March 2024, the Scottish DNA Database held DNA profiles for 397,911 individuals. There were also 20,726 crime scene profiles not yet matched to an individual giving an overall total of 418,637.

DNA profiling by SPA Forensic Services does not examine all DNA areas between individuals. Instead, the technique is designed to target the non-coding areas of DNA that are known to differ widely between individuals. This technique reveals biological sex but does not reveal physical information such as potential skin colour, hair or eye colour.

Whenever DNA is taken from an arrested person, their DNA profile is likely to be compared against profiles obtained from unsolved crime scenes held on the Scottish and UK DNA databases to identify potential suspects. DNA from crime scenes is also compared against criminal justice profiles in a similar manner to identify potential suspects. CJ DNA profiles are also automatically compared to the Prum EU DNA database holding unsolved crime scene profiles from participating EU member states.



Key findings

A decision taken by SPA Forensic Services and Police Scotland in 2014 not to re-profile DNA samples held on retention to the new DNA24 standard, and not to re-profile recidivist criminals subsequently arrested over the next ten years (including on multiple occasions) to the new standard, means that more than a decade after its introduction, 69.9% of profiles within the Scottish DNA Database have a lower statistical discriminatory power than profiles analysed by GlobalFiler™-DNA24.

There is an opportunity for Police Scotland and SPA Forensic Services to review the DNA Confirmed (DNAC) policy against the context of scientific advice highlighting that having more Criminal Justice profiles as DNA24 would reduce adventitious matches leading to more effective and efficient investigations by more speedily eliminating innocent suspects from police investigations.

The future replacement of the Scottish DNA Database, and/or enhanced connectivity with an SPA Forensic Services whole-systems core ICT solution would enhance the Crime Scene to Court model in Scotland and would improve speed and coordination across the entire forensic and criminal justice process.

A person's DNA being found at a crime scene is insufficient to infer that they were responsible for that crime as there may be many innocent reasons for its presence including transfer from elsewhere. Accordingly, it is not possible to determine how many crimes DNA helps solve in Scotland each year. However, it will be less than 0.34% of all recorded crimes and most probably fewer than 1000 crimes each year.

Most crimes in Scotland (and the UK) reported to the police do not have a forensic component meaning that quantitatively DNA does not play a statistically significant role in most police investigations or in contributing to overall crime solvency. DNA provided a potential investigative lead in 0.34% of all recorded crime in Scotland in 2023 to 2024.

The limitations of capital funding and revenue available to successive Chief Constables since the inception of Police Scotland contributed to those decisions, meaning that some of the scientific advances that the significant financial investment in DNA24 sought to achieve have not yet been fully realised.

At the time of our fieldwork in November 2024, we found that Police Scotland had no clear strategic roadmap setting out what it hopes to achieve with DNA or other biometric data and technologies in the next three, five, or ten-year period.

Although DNA has a low quantitative value in terms of its contribution to the investigation of all recorded crime, it is equally the case that DNA has a very high qualitative value when dealing with the most serious types of crime and principally because they are exposed to a forensic crime scene examination. Sometimes, the value and insights provided by DNA in an investigation can be spectacular.

Police Scotland may wish to consider whether having different biometric data types administered by different administrative teams in different locations is the most effective and efficient way to exercise sound governance of biometric data arising from the same arrest episodes. An alternative approach might be for those siloed administrative arrangements to be centralised under the direction and control of the Police Scotland Head of Biometrics.

DNA recovered from a crime scene in Scotland during 2023/24 matched to an existing criminal justice DNA profile at a match rate of 57%. Despite Scotland having more advanced DNA interpretation and analysis capability, England and Wales collectively had a significantly higher match rate at 64.8%. The most plausible explanation is simply because the volume of DNA profiles in England and Wales is much higher because of a higher population and higher crime rates and therefore more matches occur.

82.75% of Criminal Justice Profiles held within the Scottish DNA Database on 31 December 2023 were persons who are biologically male. This reflects the fact that most crime in Scotland (and the world) is committed by males.

Police Scotland does not record the ethnicity of persons within the Scottish DNA Database and does not properly record and publish data on the ethnicity of persons arrested.

DNA retained in Scotland by Police Scotland as part of a National Security Determination (NSD) is independently reviewed by the Biometrics Commissioner for England and Wales who has a wider UK function in this regard. However, the post has been gapped by the Home Office since mid-August 2024 meaning that there is currently no independent oversight being conducted in Scotland.

Summary of recommendations

No.1

Police Scotland and the Scottish Police Authority should (as part of the current review of retention policy) discontinue the practice of retaining the DNA of persons admonished or given an absolute discharge under summary procedure in Scotland (who have no previous convictions) for a period beyond average life expectancy in Scotland.

No.2

Police Scotland should take scientific advice from SPA Forensic Services and note relevant National Police Chiefs Council (NPCC) guidance before developing and documenting consistent policy on the optimal environmental storage conditions for the short-term and long-term storage of DNA buccal swabs taken for criminal justice and evidential purposes. The agreed policy for short-term and long-term storage should then be included within the Police Scotland Biometrics Standard Operating Procedure (SOP).

No.3

Police Scotland should conduct a review of the administrative arrangements for the management of evidential DNA swabs to ensure the effectiveness and efficiency of their management and to improve strategic governance and oversight.

No.4

Police Scotland should complete the development of a documented strategy in conjunction with SPA FS setting out what it hopes to achieve with DNA and other biometric data and technologies in the next three, five, or ten-year period. The plan should be approved by the Force Executive and the Scottish Police Authority and be in place by no later than 31 October 2025.

No.5

In the medium term from 2026 to 2031, SPA Forensic Services should seek capital funding to deliver a whole-system core operating solution for SPA Forensic Services that either includes the Scottish DNA Database within the core system or as an orbit system to enhance the effectiveness and efficiency of the Crime Scene to Court model in Scotland.

No.6

Police Scotland and SPA Forensic Services should review the current DNA Confirmed (DNAC) policy against the context of scientific advice highlighting that having more Criminal Justice profiles as DNA24 would reduce adventitious matches leading to more effective and efficient investigations by more speedily eliminating innocent suspects from police investigations.

No.7

Police Scotland should review its procedures for recording the ethnicity of persons who have biometric data held on SDNAD following arrest with a view to fully recording and publishing such data in support of equality duties and to promote public confidence and trust.

Introduction
About the Scottish Biometrics Commissioner

The Scottish Biometrics Commissioner is established under the Scottish Biometrics Commissioner Act 2020.

The Commissioner's general function is to support and promote the adoption of lawful, effective, and ethical practices in relation to the acquisition, retention, use and destruction of biometric data for criminal justice and police purposes by:

- The Police Service of Scotland (Police Scotland)
- Scottish Police Authority (SPA)
- Police Investigations and Review Commissioner (PIRC)

The Commissioner has wide ranging general powers and may do anything which appears to the Commissioner to be necessary or expedient for the purposes of, or in connection with, the performance of the Commissioner's functions, or to be otherwise conducive to the performance of those functions.[1]

Our Power to Work with Others

Section 3 of the Scottish Biometrics Commissioner Act 2020 confers a power on the Commissioner in the exercise of their functions to work, assist and consult with other named bodies. This includes amongst others, Police Scotland, the Scottish Police Authority and the Police Investigations and Review Commissioner.

This Assurance Review was conducted by the Scottish Biometrics Commissioner working in partnership with the Scottish Police Authority (SPA) and the Leverhulme Research Centre for Forensic Science.

The Commissioner may prepare and publish a report about any matter relating to the Commissioner's functions, and any such report must be laid before the Scottish Parliament. This joint assurance review was conducted under the provisions of Sections 2 and 3 of the Scottish Biometrics Commissioner Act 2020 and is laid before the Scottish Parliament under Section 20(2) of the Act.

Meaning of biometric data

The term 'biometric data' is defined differently in different UK legislation. However, under Section 34 of the Scottish Biometrics Commissioner Act 2020 it means *'information about an individual's physical, biological, physiological or behavioural characteristics which is being capable of being used, on its own or in combination with other information (whether or not biometric data), to establish the identity of an individual'*. Section 34(2)(c) and (d) of the Act specifies that such data may include samples taken from any part of an individual's body from which information can be derived, and the information subsequently derived from such samples. Therefore, in relation to DNA, the definition of biometric data within the Scottish Biometrics Commissioner Act 2020 includes both the source biological sample from which DNA may be extracted as well as the computerised representation of the DNA profile itself and any associated information relating to the identity of an individual acquired or retained.

[1] Scottish Biometrics Commissioner Act 2020, Section 4.

Exercising our general function

In exercising our general function, the Commissioner is required to keep under review the law, policy and practice relating to the acquisition, retention, use and destruction of biometric data by or on behalf of Police Scotland, the Scottish Police Authority (SPA) and the Police Investigations and Review Commissioner (PIRC). The Commissioner must also promote public awareness and understanding of the powers and duties these persons have in relation to the acquisition, retention, use and destruction of biometric data, how those powers and duties are exercised, and how the exercise of those powers and duties can be monitored or challenged.

Details of how we exercise our general function can be viewed in our Strategic Plan 2021/25. When discharging our statutory functions, we use our National Assessment Framework to consider strategic direction, execution, and results in relation to biometric data used for criminal justice and policing purposes by the bodies to whom our functions extend. Our framework can be found as an Appendix to our Code of Practice.

About the Scottish Police Authority

The Police and Fire Reform (Scotland) Act 2012 created the Scottish Police Authority (SPA) and set out its five core functions:

- to maintain the Police Service
- to promote the policing principles set out in the 2012 Act
- to support and promote continuous improvement in the policing of Scotland
- to keep under review the policing of Scotland; and
- to hold the Chief Constable to account for the policing of Scotland

These five functions demonstrate the dual, integrated responsibilities of the SPA: its oversight role in scrutinising policing in Scotland and holding the Chief Constable to account; and its supportive role in maintaining and improving the police service.

SPA is also responsible for the management and delivery of Forensic Services in Scotland, and it is worthy of note that SPA Forensic Services is the largest public sector provider of forensic services in Europe. The Authority aims to increase public trust and confidence in the policing of Scotland in the way it discharges its functions and through the quality of its governance arrangements. Further information can be found on the SPA website.

About the Leverhulme Research Centre for Forensic Science

The Leverhulme Research Centre for Forensic Science (LRCFS) is based at the University of Dundee. It is an interdisciplinary research team, the largest in the UK, dedicated to the improvement of the robustness and quality of the science underpinning evidence presented within the criminal and civil courts.

LCRFS is a ten-year £10 million project with the remit to develop the current forensic science ecosystem by collaborating with academics, industry, and practitioners from crime scene to court to drive innovation that enables reliable science to be used in the delivery of justice. The Centre has a vibrant, dynamic, and agile team blending public engagement, statistics, natural sciences, social sciences, and legal domains together to solve real world problems. Further information can be found on the Leverhulme Research Centre for Forensic Science website.

Foreword
By the Scottish Biometrics Commissioner

The strategic aim of this joint review is:

"to provide assurance to the Scottish Parliament that the acquisition, retention, use, and destruction of DNA for policing and criminal justice purposes in Scotland is lawful, effective, and ethical."

The review has considered the nature and extent of the uses of DNA for policing and criminal justice purposes in Scotland including the impact of such use in terms of outcomes. This included, but was not limited to examining:

- the law and Police Scotland policy
- the lawful use of DNA for policing and criminal justice purposes in Scotland
- process, including assessing the effectiveness of DNA both in fixing and confirming identity, also in terms of match rates, its exculpatory value, and in contributing towards overall crime solvency in Scotland
- the ethical considerations around the current and future use of DNA including whether the current retention regimes are proportionate and necessary. This aspect was linked to the joint Scottish review of the laws of retention in Scotland published by Scottish Government and the Commissioner in October 2024

The specific methodology for this review, including matters excluded from scope, was outlined in a Terms of Reference agreed between partners and published on our website in August 2024. Our judgements are based on our National Assessment Framework for biometric data outcomes which ensures a consistent and objective approach to our work.

Our National Assessment Framework considers six overarching themes, namely:

- Leadership and governance
- Planning and process
- People
- Resources
- Partnerships
- Outcomes

My expectation as Commissioner is that any recommendations from our assurance reviews will result in an action plan by the organisation(s) to whom they are directed and taken forward to enable relevant good practice to be disseminated across Scotland to promote continuous improvement. I will monitor actions to address any recommendations made and will report on progress and outcomes in my Annual Report to the Scottish Parliament. Where a recommendation is made to Police Scotland, Scottish Police Authority will also monitor progress through normal mechanisms for holding the Chief Constable to account.

I wish to extend my thanks and appreciation to the Scottish Police Authority and the Leverhulme Research Centre for Forensic Science our strategic partners in this review. Thanks, are also due to Detective Chief Superintendent Suzie Chow who at the time of our fieldwork led on Major Crime, Public Protection and Local Crime and Wildlife Crime, and to Gillian Jones the Head of Biometrics for Police Scotland and Diana Dundas, Biometric Data Lead.

Thanks, are also due to the many officers and staff from Police Scotland who assisted our review and to SPA Director of Forensic Services and her team of managers, forensic scientists, and staff.

Our joint assurance review was jointly led by myself and Cheryl Glen, SBC Corporate Services Manager assisted by the SBC Director, SBC Business Support Officer and Scottish Police Authority and Leverhulme colleagues.

Dr Brian Plastow
Scottish Biometrics Commissioner
February 2025

Findings
i. The nature of the use of DNA in policing in Scotland

Overview

This first findings chapter engages with the 'nature' of the use of DNA in policing in Scotland by:

- Providing a basic introduction to the science of DNA and molecular biology including how it is used in policing and in forensic science in Scotland.
- Providing a brief history of its application to policing and how it has evolved.
- Explaining the legal framework provided by the Criminal Procedure (Scotland) Act 1995 and other relevant legislation for the acquisition of DNA samples from persons arrested by the Police and otherwise on a voluntary basis for purposes such as elimination.
- Explaining the basics of criminal justice DNA sampling procedures.
- Exploring the basics of evidential DNA sampling procedures.
- Helping non-scientists to understand the basics of DNA extraction and profiling.
- Signposting to further sources of reading and the related work of other oversight bodies.

Introduction to the basics of DNA, its use in policing and Scots law

The term 'DNA' is an abbreviation of deoxyribonucleic acid. In simple terms, it is a chemical store of the genetic information for all living things. It is a chemical made up of two long strands, arranged in a spiral. This is the double-helix structure. DNA carries genetic information - the genetic code. It has all the instructions that a living organism needs to grow, reproduce, and function. DNA is passed on from parents to their biological offspring during fertilisation.

DNA is made from four base pairs. These are made from the DNA bases of the four letters that make up the genetic code: A and T, G and C. These can be either way around, but A always pairs with T and G with C. The base pairs are held together by weak chemical hydrogen bonds.

This means that when the strands separate, each one can function as a template to reproduce the other precisely. The linear sequence of bases can function as a code, providing the instructions for many biological functions. Each cell in the human body contains 6,500,000,000 pairs of bases.

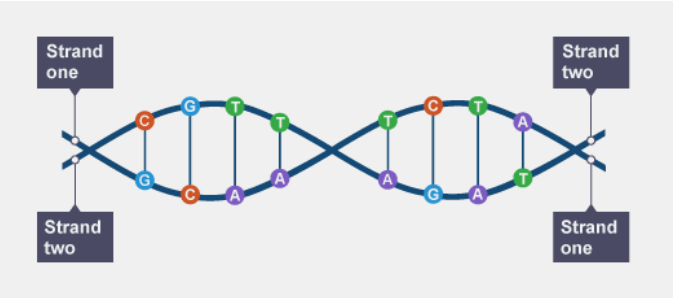


Figure 1. The double helix structure of DNA (*Source.* BBC Bitesize)

All life on Earth has the same basic genetic code. The same four letters make up bacteria, fungi, animals - including humans, plants and single-celled organisms. DNA is present in the nucleus (centre) of almost every cell in your body. In fact, there are around two metres of DNA packed into each nucleus of your body cells. Your sex cells or gametes, sperm, or ova, only have half of this to enable the male cells to join with female cells during fertilisation.[2]

DNA contains the information for biological life using a genetic code encoded within a sequence of bases along the double helix molecule, meaning that forensic scientists can 'read' that code to compare the potential of any given sample.

A complete DNA sequence is unique to each person - apart from an identical twin (monozygotic twin) who has the same DNA as their twin, unless a mutation has occurred However, there are rare exceptions to this general scientific rule. For example, organ donor recipients have been found to carry both their own DNA and the DNA of the donor. This phenomenon is known as recombinant DNA or chimeric DNA. Recombinant DNA (rDNA) is the general name for a piece of DNA that has been created by combining two or more fragments from diverse sources, for example through organ transplant, or through genetic engineering including cloning.

From DNA to genome: understanding molecular biology

Genes are small sections of DNA that are the genetic code for an inherited characteristic such as ear shape or eye colour. Genes are sections of DNA that code for specific proteins or functional ribonucleic acid (RNA).[3]

You inherit pairs of genes for most characteristics from each of your biological parents. Alleles, on the other hand, are different versions of the same gene. Understanding these differences is crucial to studying inheritance patterns such as eye colour, with one gene in each pair coming from each parent.[4] Full siblings will on average share half of their DNA. There are around 23,000 genes that make up a human.

Genes are arranged into larger structures called chromosomes (a supercoiled structure of DNA found in the nucleus of cells made from many genes). Humans have twenty-three different pairs of chromosomes or forty-six chromosomes in total. The sex of humans is determined at the point of fertilisation by the combination of sex chromosomes received from the parents. In general, females receive two X chromosomes, represented as XX. Males receive an X and a Y chromosome, represented as XY.[5]

All the chromosomes of an organism add up to make its genome. This is one copy of all its DNA. Every human on Earth has a unique genome[6] unless they are identical twins (fraternal) who were made from the same fertilised ovum (monozygotic) (egg cell). Non-identical twins were made from two separate sperm fertilising two different ova (egg cells) and so have different genomes. The genome is found in the nucleus or centre of almost every body cell.

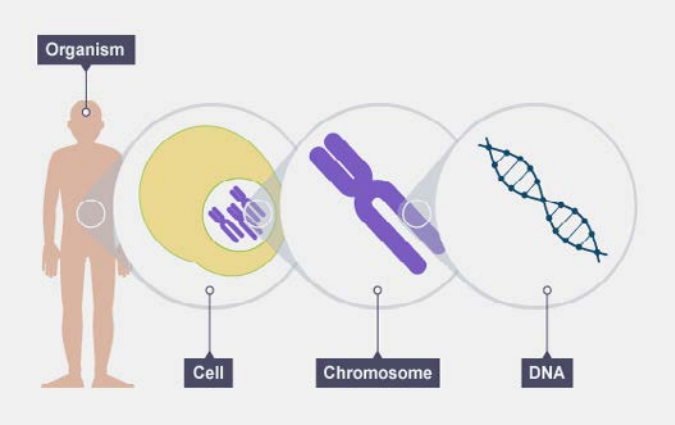


Figure 2. Human biology and DNA (*Source.* BBC Bitesize)

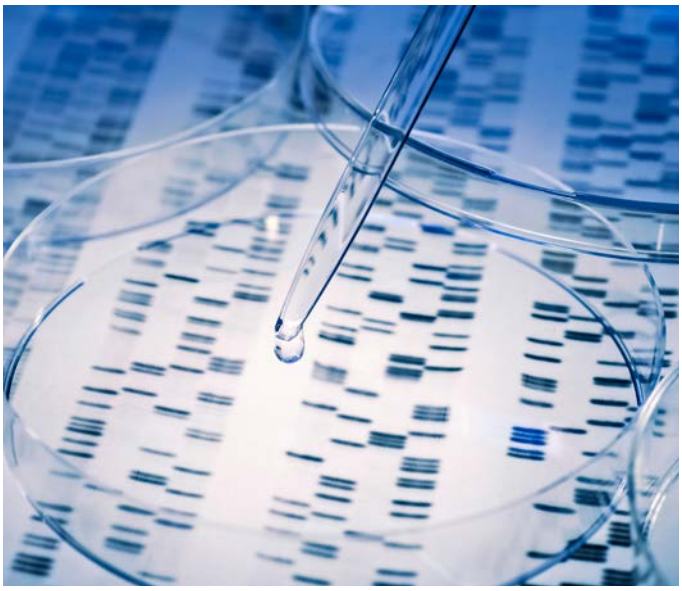
[2] BBC Bitesize, DNA – Inheritance and genetics – KS3 Biology – BBC Bitesize, accessed 23 November 2024.
[3] Ribonucleic acid (RNA) is a molecule present in most living organisms and viruses.
[4] An allele, or allelomorph, is a variant of the sequence of nucleotides at a particular location, or locus, on a DNA molecule.
[5] BBC Bitesize, *ibid*.
[6] Subject to the earlier observation on recombinant or chimeric DNA.

DNA makes up genes which make up chromosomes which make up the genome within a cell and collectively these are the building blocks of life. A good conceptual model for thinking about molecular biology is astronomy where the planet Earth is the DNA, our solar system is the chromosome, the galaxies are our individual cells, and all of which combine to form part of the universe which is our body.

Short tandem repeats (STRs)

Only small non-coding sections of DNA are analysed routinely for policing and forensic science purposes. The parts analysed are called short tandem repeats (STRs). Mutations that effect the number of repeats is common, so within a population there are usually several different versions of the DNA (alleles) at an STR locus with different number of repeats and lengths.

The frequency of the occurrence of a specific allele at the tested locus in a specific population provides a measure of how common that allele is in that population. This information is essential for calculating match probabilities. If only one STR was analysed, there would be many people with the same allele, purely by chance.



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It is therefore necessary to analyse different STR loci to ensure that the chance of two unrelated people having matching DNA profiles is exceedingly small. The confidence levels of match probability calculation accuracy therefore increase exponentially as the number of STR loci analysed is increased. This means that modern DNA analysis is even more discriminatory than it was previously. DNA interpretation and analysis is scientifically the most accurate and reliable of all biometric technologies currently used in world policing. However, readers should understand that there is no such thing as a biometric technology which is 100% perfect. This includes DNA, where samples could be inadvertently contaminated at any stage in the process from recovery to the laboratory, and which like all science, is also exposed to the inevitable risk of human or ICT error resulting in inaccurate results, unreliable evidence and miscarriages of justice. In this regard, matches between the DNA of different people sometimes occur by chance when only a partial profile is recovered from a crime sample. This is known as an adventitious match. Elimination databases are held separately to other searchable databases which hold SPA FS staff members, other laboratory visitors and some Police Officers. Lab contaminations are monitored and investigated prior to a result being issued to ensure that the integrity of the same result is robust.

Importantly, DNA is used extensively in policing to eliminate innocent persons from police enquiries and to correct miscarriages of justice. This aspect was brought into sharp relief in 2023 through the case of Andrew Malkinson who spent 17 years in prison for a 2003 rape in Solihull with no DNA linking him to the crime. It was later discovered by the Criminal Cases Review Commission that a forensic review conducted five years after the original conviction discovered a searchable male DNA profile on the victims clothing which was not Mr Malkinson. It was also reported that Greater Manchester Police had known this but failed to properly investigate leaving an innocent man incarcerated until the actual offender was identified and convicted through DNA evidence many years later.[7]

[7] Andrew Malkinson -v- The King, UK Court of Appeal, case number 202300268 B4.

Y-STR analysis

A second form of DNA analysis used in policing and forensic science involves study of loci found only on the male specific Y chromosome. Currently, there is no useable databasing facility in the UK which can be added to or searched. Y chromosome DNA is inherited by sons from their biological father with little change between generations. Therefore, the profiles generated from Y chromosome DNA are remarkably similar between males with a shared male ancestor, with only exceedingly rare mutations leading to differences between males who share their Y chromosome. Analysing Y chromosome STRs can be helpful where there is a mixture of DNA from male and female contributors, for example, in a sexual assault investigation where female DNA might overshadow male DNA. It is also a valuable tool to trace family relationships among males, to help identify missing persons, and to assess paternal relationships when the alleged father is not available.

Moreover, the Y chromosome is hugely significant in policing terms as most crime in Scotland is committed by men, and often against women. Therefore, Y chromosome DNA analysis is helpful in contributing towards strategic policing strategies to address the national emergency of male violence towards women and girls.

Mitochondrial DNA

Mitochondrial DNA is not found in the nucleus of cells, but in the mitochondria. It is associated with the energy production functions of the cell. Mitochondrial DNA is inherited solely down the maternal line. Mitochondrial DNA analysis is very different from STR analysis, and the results are far less powerful for distinguishing between individuals (1 in 100 being a typical match probability). However, it can still be used to eliminate a suspect conclusively. The main advantage of mitochondrial DNA is that it is less sensitive to factors such as age and environmental conditions. Therefore, it is particularly useful for analysing decomposed tissue and material from fires.

It is also possible to use this technique to analyse samples such as faeces, bone and hair shafts, which cannot be analysed using STR methods. Currently, the analysis of mitochondrial DNA is very time consuming and expensive. Mitochondrial DNA profiles are not comparable with STR profiles and therefore cannot be loaded onto the Scottish DNA Database (SDNAD) or the UK DNA Database (NDNAD). This technique is not one used by SPA FS as it has no probative value in police investigations.

The first scientific discovery of DNA

DNA was first discovered in 1868 by Friedrich Miescher, a Swiss scientist who isolated it from white blood cells. However, the structure of DNA was only first revealed in 1953 by James Watson and Francis Crick, two British scientists who used X-ray images of DNA previously taken by a student of British chemist Rosalind Franklin to deduce its double helix shape. Their collective discoveries marked a milestone in the history of science and gave rise to modern molecular biology.

Friedrich Miescher © Wikimedia Commons

The first use of forensic DNA profiling in policing

Forensic science operates, by definition, within a legal context and has revolutionised forensic science. The first report concerning the use of DNA profiling in a criminal investigation in the UK (and in the world) was published in 1987. This followed a double rape and murder in Leicestershire that occurred three years apart in 1983 and 1986. This led to the production of the first forensic DNA profile produced to assist a police investigation which showed that both murders had been conducted by the same individual, who was not the prime suspect. Leicestershire Constabulary then conducted the world's first DNA intelligence-led screening. All adult males in three villages – a total of 5,000 men – were asked to volunteer and provide blood or saliva samples. A local baker, Colin Pitchfork, was arrested, and his DNA profile matched with the semen from both murders. In 1988 he was sentenced to life imprisonment for the two murders.

Sir Alec John Jeffreys by Jane Gitschier © Creative Commons

The work was pioneered at the University of Leicester by (now) Sir Alec John Jeffreys a British geneticist known for developing the techniques for what was then known as genetic fingerprinting and is now known as DNA profiling and which are now used worldwide in forensic science. Queen Elizabeth II knighted Alec John Jeffreys in 1994 for services to genetics.

The first successful profiling of DNA in Scotland for policing purposes was conducted by forensic scientists working for the former Strathclyde Police in 1990. It took the scientists weeks to complete the chemical extraction of a single profile. Over time, the number of STR loci analysed has increased as technology has developed. SPA Forensic Services currently uses GlobalFiler™-DNA24 which is a highly sensitive and discriminatory technique. This is the most advanced DNA profiling currently used in world policing meaning that Police Scotland and other criminal justice partners in Scotland benefit from more advanced forensic science than is available routinely in many other parts of the UK or in the European Union. Some of the DNA24 loci are included in the USA Codis DNA profile and held on their database maintained by the FBI.

However, and as will be discussed in following chapters of this report, ten years after the introduction of DNA24, a decision taken by Police Scotland in 2014 not to re-profile physical samples held on retention to the new standard, and an associated policy decision not to re-sample recidivist criminals subsequently arrested and already DNA confirmed to that higher standard means that more than a decade after its introduction, around 69.9% of profiles within SDNAD have a lower discriminatory power than DNA24. As will be discussed later in this report, the Commissioner is concerned that the limitations of capital funding available since the inception of Police Scotland contributed to those decisions meaning that some of the scientific advances that the significant financial investment in DNA24 sought to achieve have not yet been fully realised.

Lawful basis for acquisition and use of DNA in Scotland

Criminal procedure legislation in Scotland (and corresponding legislation in other parts of the UK) permits the police to obtain biological DNA samples (normally using buccal mouth swabs) without consent from any person detained following arrest for a recordable offence. The Criminal Procedure (Scotland) Act 1995, Sections 18 and 19 as amended, sets out the law relating to the taking of such samples in Scotland. This includes provisions for samples to be taken from certain categories of individuals, and for the resulting DNA profiles to be retained on a DNA database.

Section 18A of the 1995 Act provides that for criminal proceedings in respect of a relevant sexual or violent offence that conclude other than with a conviction, that the destruction date for any relevant data taken under Section 18(2) or any sample or any information derived from the sample is the date of expiry of the period of three years following the conclusion of the proceedings; or such later date as an order under subsection (5) may specify. Subsection (5) provides that the Chief Constable of the Police Service of Scotland can apply to the Sheriff Court within the period of three months before the destruction date to have the destruction date amended. As the process is subject to judicial oversight, this affords transparency and accountability to the decision-making.

Under Section 18B of the 1995 Act, if a person accepts an offer under Sections 302 to 303 of the 1995 Act (conditional offer, compensation offer, combined offer, work offer), then any relevant physical data or sample that they have provided, or information derived from such a sample, must be destroyed within either two or three years beginning on the date on which the offer was issued (depending on whether a relevant sexual or violent offence was involved) or (in the case of a relevant sexual or violent offence only) any later date as an order may specify. Such an order may be sought by summary application by the Chief Constable under Section 18C.

Section 18D of the 1995 Act provides that when a person is arrested in relation to a fixed penalty offence and the matter is dealt with by fixed penalty notice that any relevant physical data taken in connection with that offence must be destroyed within two years of the day on which the fixed penalty notice was given to the person. The difference is explained by the nature of the offence to which each provision relates – Fixed Penalty Notices (FPN) (issued by Police Scotland) are for minor public nuisance offences, whereas Fiscal Offers (issued by COPFS) are for a higher degree of offending but not for serious (public safety) offences.

Section 19AA of the 1995 Act also makes provision around the taking of relevant physical data or samples from sex offenders subject to notification requirements under the Sexual Offences Act 2003 or an order under Section 27 of the Abusive Behaviour and Sexual Harm (Scotland) Act 2016.

Section 19AA of the 1995 Act makes supplementary provision principally around the provision of an offence where a person fails, without reasonable excuse to attend a police station to provide a sample or whilst in custody at a police station fails to allow a sample to be taken. Section 19B makes provision in relation to the powers of a constable to take relevant physical data or to secure a person's compliance to take such data.

The Criminal Justice (Scotland) Act 2003, Section 56, facilitates the taking of DNA samples for recording on the Volunteer DNA database. The investigation of crime in Scotland is also covered by common law and other legislative acts.

In Scotland, DNA is acquired from arrested and officially accused persons in accordance with Police Scotland policy normally after a decision has been made that the subject is to be cautioned and charged, and providing that the person is not already DNA confirmed, meaning that Police Scotland already hold a DNA profile for the person.

Police Scotland may also take samples from not officially accused (NOA) persons if an investigation is still live, as this negates the need to re-arrest a person purely to obtain biometric data if they subsequently become officially accused.[8] Police Scotland has a policy in place to ensure weeding if charges are not forthcoming and if there are no proceedings.[9] Police Scotland also have arrangements and policy for obtaining DNA from certain vulnerable persons on a voluntary basis, for example when there is a significant risk that such a person may be abducted or become a victim of crime. The Crown Office and Procurator Fiscal Service (COPFS) will also sometimes issue a warrant for the arrest of an accused person with powers to take a DNA sample attached. This could be in circumstances where Police Scotland has been unable to trace a person following a DNA match to obtain evidential samples, or in other circumstances such as where a person wanted in Scotland is arrested in another part of the UK and is brought to Scotland for appearance in court.

The DNA profile generated from the criminal justice sample is loaded onto the Scottish DNA Database (SDNAD) and the UK National DNA Database (NDNAD) and is then used in speculative searches for matches to pre-existing or new crime scene profiles. In Scotland, if a person is subsequently convicted, the Criminal Procedure (Scotland) Act 1995 sanctions indefinite retention of their DNA. However, it is important to note that indefinite retention without periodic review is not permitted by the UK Data Protection Act 2018, or by the Scottish Biometrics Commissioner's statutory Code of Practice which requires adherence to UK data protection law. In October 2024, the Commissioner and Scottish Government published a joint Review of the Laws of Retention in Scotland which included a recommendation for Police Scotland to complete a review of retention policies by October 2025. The Commissioner and Scottish Government recommendation is that any revised policy must include periodic review.

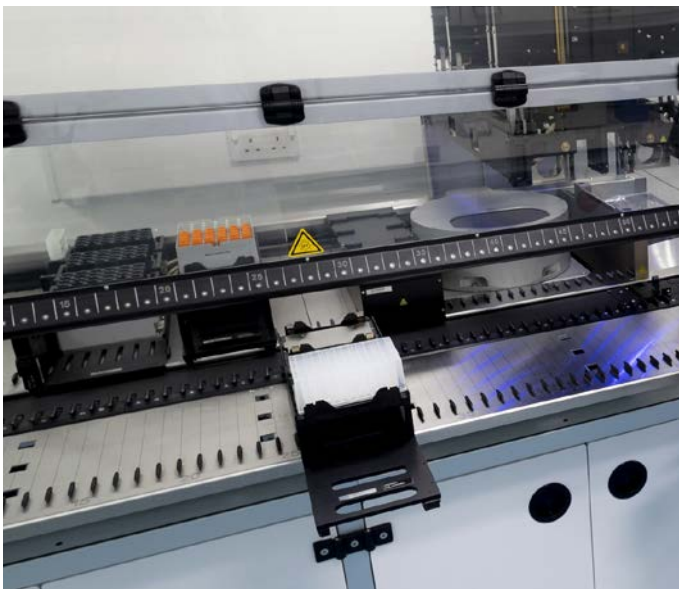
In Scotland, Police Scotland may only retain and use samples from non-convicted persons or in cases of non-finding of guilt under the provisions of Section 18A of the Criminal Procedure (Scotland) Act 1995 (prosecutions for sexual and violent offences), or Sections 18B and D (alternatives to prosecution) for up to three years. The Act also makes provision for retention beyond three years on summary application by the Chief Constable to a Sheriff. In England and Wales, the provisions of the Protection of Freedoms Act 2012 directs that the DNA of persons innocent of any offence must be destroyed within 6 months of being taken.[10] The only exception to this is, if the sample is required for use as evidence in court, in which case it may be retained for the duration of the proceedings, under the Criminal Procedure and Investigations Act 1996.

The ability to retain and use a convicted person's DNA indefinitely regardless of the gravity of offending in the UK is highly controversial. The UK National DNA Database, which during 2025 celebrates the 30th anniversary of its establishment, is both the oldest and largest state collection of citizens DNA data in the world when the numbers of profiles on retention is expressed as a percentage of the domestic population. The longstanding practice in the UK of adding more and more DNA to national policing databases and keeping it there for extraordinarily long periods of time, helps to explain why the volumes of data on retention continue to increase resulting in significant governance challenges as illustrated through 17% of the DNA profiles retained on the UK NDNAD in 2023/24 being duplicates.[11]

[8] See Criminal Justice (Scotland) Act 2016 for further information on persons not officially accused.
[9] Police Scotland Records Retention SOP version 7.0.
[10] Independent oversight of DNA retained in England and Wales is conducted by the Biometrics and Surveillance Camera Commissioner.
[11] Forensic Information Databases annual report 2023 to 2024.

The exponential growth of data within such databases also means that governance and administrative arrangements around retention increasingly becomes difficult for humans to manage because of the sheer volume. Recognising that volumes of data in SDNAD are also increasing exponentially because of lengthy retention periods, there are questions to be asked about how best to administer 'big data' that is so complex that is becomes difficult using traditional data-processing applications.

Although beyond the scope of this review, it is also worth mentioning for completeness that the Chief Constable of Police Scotland may retain DNA (and fingerprints) from an un-convicted person as part of a National Security Determination (NSD) under the Protection of Freedoms Act 2012. The Home Office publishes Guidance on the making or renewing of national security determinations. NSD's (including those made by Police Scotland) are independently reviewed by the Biometrics Commissioner for England and Wales. However, this post has been gapped by the Home Office since mid-August 2024 meaning that there is currently no independent oversight being conducted in Scotland.



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DNA extracted from biological materials from crime scenes

DNA can also be recovered from biological materials at crime scenes as part of a forensic investigation, and DNA profiling is a forensic technique used in criminal investigations and in a range of other policing activities such as missing person investigations, or in seeking to identify human remains. Police Scotland and the SPA Forensic Services have power at common law in Scotland to seize evidential materials for the purposes of the investigation, prevention, and detection of crime. The general duties of a constable to prevent and detect crime and protect life and property are also made explicit in Section 20 of the Police and Fire Reform (Scotland) Act 2012.

DNA profiling also enables the comparison of criminal suspects' profiles to biological evidence to assess the likelihood that the DNA originated from someone other than an unrelated to person A. It also has an important exculpatory (exclusionary) value and can quickly eliminate innocent persons from police investigations. There are also various other circumstances where the police might obtain a DNA sample from a person on a voluntary basis. This could include samples taken from victims of crime or witnesses for elimination purposes, or from family members to assist in missing person or unidentified body investigations through kinship matching, including in mass casualty enquiries.

Importantly though, readers should understand that DNA is not used routinely in police investigations in Scotland and most crimes reported to the police are not the subject of a Forensic Services crime scene examination. Instead, it is usually only a feature of more serious crimes such as murders, serious assaults and sexual offending. It is also used where organised crime is suspected and in volume crime such as housebreaking and motor vehicle thefts. Where biological evidence exists at such crime scenes and is recovered in sufficient quality and quantity, it can identify potential suspects with sufficient legitimacy.

Criminal Justice, evidential, and volunteer DNA sampling and retention

When a person is arrested in Scotland, the police have lawful authority under the Criminal Procedure (Scotland) Act 1995 to take a DNA sample, usually a mouth swab. This is known as a criminal justice sample.

As part of our review, we examined the Police Scotland and Scottish Police Authority Biometrics Standard Operating Procedure (SOP) being used in October 2024 (version 1.0 issued on 22 September 2022). We noted that the SOP had been subject to an Equality and Human Rights Impact Assessment (EqHRIA) conducted on 29 May 2018. The SOP provides operational guidance to officers and staff working within the custody environment in relation to matters within the scope of this assurance review including:

- Criminal Justice (CJ) Sampling (Green administration card – Form DNA 1)
- Evidential DNA Sampling (White administration card – Form DNA 2)
- Voluntary DNA Sampling (Pink administration card – Form DNA 3)

At the point of our fieldwork, we were aware that Police Scotland was updating the SOP to include amongst other things the new policy in relation to taking less biometric data from children as introduced through policy instruction in March 2024 in response to a previous recommendation made by the Commissioner from our 2023 Assurance Review report to Parliament on the acquisition of biometric data from children and young people arrested by the police.

At paragraph 2 of the SOP, custody staff are instructed that it is not necessary to take DNA from an individual whose Criminal History System (CHS) record indicates they are DNA confirmed (DNAC). The SOP also covers guidance on Evidential DNA samples which are normally samples taken from an accused person for comparison with crime scene evidence including for reasons of fairness to an accused in circumstances where DNA evidence already recovered at a crime scene was matched to their DNA on record because of an earlier conviction. Therefore, the purpose of taking the new sample for comparison to the crime scene evidence is sometimes specifically to avoid the leading of evidence which would reveal previous convictions on the part of the accused.

The SOP also covers guidance on Voluntary Sampling which are samples taken under the provisions of Section 56 of the Criminal Justice (Scotland) Act 2003. This is persons who have supplied their written consent to have a DNA sample taken in connection with the investigation of an offence.

There are two databases utilised in this area: the Intelligence Database and the Volunteers Database. Samples held on the Intelligence Database are held for a specific purpose and for a specific period and may only be searched in connection with the specific purpose for which they were acquired, for example an intelligence led screen to eliminate someone from an enquiry. Samples held on the Volunteers Database are searched against all outstanding crimes scenes and are also exported to the UK National DNA Database (NDNAD). This may include for example persons who are at risk of so-called Honour Based Violence (HBV).

At the point of reviewing Police Scotland Standard Operating Procedures in October 2024, Police Scotland also had a Records Retention SOP (Version 7: published 29/11/2020). On page 24 of the SOP, at item reference BIO-001, the SOP confirms that in cases of finding of guilt, Police Scotland policy is to retain the subjects DNA until their 100th birthday or until 3 years after death, whichever is sooner. We understand that this SOP was updated in August 2024 but had not been published at the time of our fieldwork.

Principle 1 (lawful authority and legal basis) of the Scottish Biometrics Commissioner's Code of Practice approved by the Scottish Parliament on 16 November 2022 provides that case files for biometrics data should be regularly reviewed and weeded in line with procedures that comply with the Fifth Data Protection Principle (Section 40, DPA 2018). Principle 12 of the Code (retention authorised by law) also provides (page 32) that data retention policy should reflect the European Court of Human Rights ruling in Gaughran-v-United Kingdom regarding the need to consider the proportionality of any interference with Article 8 rights that results from indefinite retention without periodic review.

The disproportionate character of the indefinite retention of DNA by Police Scotland and failure to keep under periodic review the retention of an individual's DNA having regard to the specifics of the case potentially brings Police Scotland into conflict with the law. However, it is acknowledged that together with Scottish Government, the Commissioner has already made a recommendation from the Review of the Laws of Retention in Scotland for Police Scotland to review biometrics retention policy by no later than 31 October 2025, and to establish revised policy which must include periodic review. The Commissioner is also mindful that the volume of biometric data held by Police Scotland (in common with all UK police forces) is such that investment in a technical solution will inevitably be required to facilitate the transition from a policy of blanket minimum retention that has persisted for decades, to one of individualised regular periodic review having regards to the specifics of an individual case.

In this regard, and as part of the review of retention policy in response to recommendations made by the Commissioner and Scottish Government in October 2024 there is a need for Police Scotland to consider the gravity of offending in the formulation of retention policy to ensure that it reflects the proportionality and necessity of retention in individual cases. For example, during our fieldwork visits the Commissioner was concerned to learn that even in the case of admonishment or absolute discharge under summary proceedings, and where the subject has no previous convictions, Police Scotland will still retain a person's DNA until at least their 100th birthday or three years after death whichever comes sooner.[12] As Police Scotland hold no management information to justify such extraordinarily long retention periods in cases of admonishment and absolute discharge under summary procedure the policy will come into conflict with the Scottish Code of Practice if it is not changed as part of the current review as it is neither proportionate or necessary.

Accordingly, it is recommended that in developing a new retention policy, Police Scotland and the Scottish Police Authority should discontinue the blanket practice of retaining the DNA of persons beyond average life expectancy in Scotland in circumstances where they are admonished or given an absolute discharge under summary procedure, providing that they have no previous convictions. Whilst it is recognised that an admonishment or absolute discharge under summary procedure are technically convictions, it would seem more proportionate to the Commissioner for the retention period of such data to be aligned with prescribed retention periods for direct measures such as recorded police warnings.

[12] Admonished is where a person is found guilty but where the offence is trifling or there are special circumstances relating to the offence or the person. Under the Rehabilitation of Offenders Act 1974, there is no disclosure period in respect of admonition, and it is considered spent immediately. An absolute discharge under summary procedure is where no punishment is given. In solemn (more serious cases) a conviction is recorded. An absolute discharge under summary procedure is spent immediately.

Recommendation No.1

Police Scotland and the Scottish Police Authority should (as part of the current review of retention policy) discontinue the practice of retaining the DNA of persons admonished or given an absolute discharge under summary procedure in Scotland (who have no previous convictions) for a period beyond average life expectancy in Scotland.

Further information on the retention of DNA can be found in the joint review published by the Commissioner and Scottish Government in October 2024.

Taking, storing and transporting DNA Mouth Swabs (buccal swabs)

The Police Scotland and Scottish Police Authority SOP explains the sampling procedure for taking mouth swabs including health and safety measures, contamination prevention measures, ensuring that samples are correctly labelled and placed in tamper proof bags, and cultural and religious sensitivities to be observed in certain circumstances.

Figure 3. Capture of DNA from skin cells via mouth swab

The SOP requires that two buccal mouth swabs be taken for criminal justice purposes and where required, a further two buccal mouth swabs may be taken for evidential purposes. In each case, the purpose of taking two samples is to have a second biological source sample available should profiling of the first sample fail. Having a second sample available for this purpose, or for re-visiting as part of a cold case investigation, or for re-profiling as DNA technologies advance is acknowledged as effective practice by the Commissioner.

The notable absence from the Police Scotland and SPA SOP is any form of guidance for police staff regarding under what environmental conditions such biological materials should be retained whilst in the custody environment or where it should be held locally (for example by local CID) and guidance during subsequent handling and transportation to the Police Scotland DNA Administration Unit in Dundee and/or on to the laboratory. Biological materials containing DNA are stable when kept at room temperature for short periods of time, but they can degrade quickly if exposed to temperatures above 24 degrees Celsius or where humidity exceeds 60%.[13] In addition guidance is essential for reasons of consistency and to ensure that operational practices protect biological samples from being degraded by freezing and thawing cycles, or by being exposed to UV radiation, temperature extremes, pH extremes, and environments containing materials with high salt concentrations.

Because of the nature of the evidence storage and management process, and the different routing of criminal justice and evidential samples, it is also necessary for Police Scotland to properly distinguish temporary storage conditions guidance from long-term storage guidance. Temporary storage spaces include small property rooms or fridges in police stations, or vehicles that transport evidence from the custody facility to long-term evidence management facilities and/or the laboratory.

[13] Forensic Capability Network UK and U.S. National Institute of Science and Technology.

During a fieldwork visit to Livingston police station on 6 November 2024, the Commissioner and his team noted that criminal justice DNA samples (buccal swabs) were being stored in a freezer but evidential DNA samples (buccal swabs) were being stored in a fridge despite manufacturers guidance on the DNA Evidential Mouth Swab Kit – K521 clearly stating that samples should be stored at or below minus fifteen degrees celsius. In both cases, samples were then transported elsewhere under ambient conditions.

For those reasons, the Commissioner recommends that Police Scotland should take scientific advice from the SPA Forensic Services before developing a short-term and long-term storage matrix to inform policy, and guide staff on the optimal environmental and storage conditions for buccal mouth swabs or other biological materials of a criminal justice or evidential nature. Once developed, the storage matrix guidance should be included in the Police Scotland and SPA Biometrics SOP. In developing such guidance, Police Scotland should have regard to National Police Chiefs Council (NPCC) guidance on such matters including guidance issued in 2024 on the Retention, Storage and Destruction of Materials and Records relating to Forensic Examination, where on page 27 the storage matrix recommends that DNA swabs should be stored in a freezer with a temperature range between minus 15 and minus 30 degrees celsius.

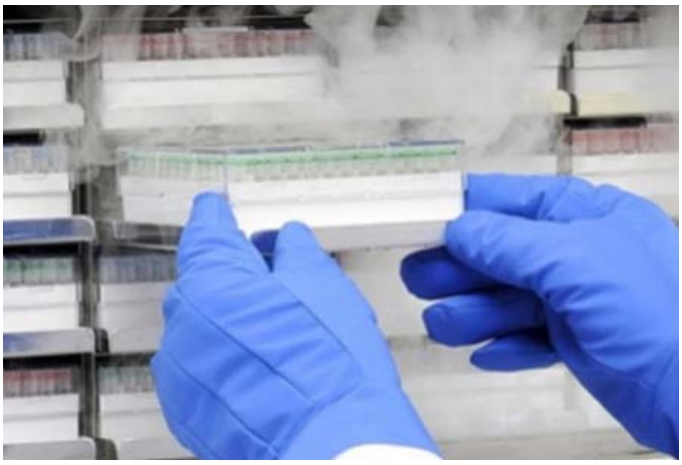


Figure 4. DNA samples stored in frozen conditions

Recommendation No.2

Police Scotland should take scientific advice from the SPA Forensic Services and note relevant NPCC guidance before developing and documenting consistent policy on the optimal environmental storage conditions for the short-term and long-term storage of DNA buccal swabs taken for criminal justice and evidential purposes. The agreed policy for short-term and long-term storage should then be included within the Police Scotland Biometrics SOP.

In the case of non-compliant prisoners who refuse to provide DNA via buccal mouth swabs, the Police are authorised by the Criminal Procedure (Scotland) Act 1995 to use reasonable force to obtain the sample. In such circumstances, Police Officers may instead take hair samples in preference to using a technique which might impact on the subject's airway. This is catered for in the Police Scotland and SPA SOP which directs that at least 10 hairs should be plucked from the head of the suspect ensuring that the root sheaths are attached to the hair samples.

In practice, most people arrested by the police comply with the procedures for DNA sampling and it is exceptionally rare for officers to have to resort to the use of reasonable force. Where it is necessary, this information is captured on the Police Scotland custody system and any use of reasonable force is communicated in the relevant report to the Procurator Fiscal.

Criminal Justice sample journey

Criminal Justice samples taken in the custody environment follow the following sample journey:

- custody staff collate batches of CJ DNA samples into a secure bag, each with a unique bag seal ID
- contained within each individual bag should be a list of contents, i.e., Barcode and nominal. (Force Form 053-007 can be used, or any version that replicates the contents)
- samples are uplifted and delivered by either local Police Scotland civilian drivers or via SPA Forensic Services' (SPA Forensic Services) logistics business partner for delivery to the Criminal Justice DNA Administration Unit in Rushton Court
- this process provides an audit trail for transfer and ensures no samples can be tampered with during transition
- priority samples can be hand-delivered to staff at Rushton Court, rather than waiting to go with the next batch uplift

Criminal Justice DNA Administration Unit

The Police Scotland central Criminal Justice DNA Administration Unit in Dundee was established in 2014 to deliver a centralised sample triage and administration function. As such, it serves as the central reception point for all criminal justice DNA swabs before onward travel to the co-located SPA Forensic Services laboratory. The Head of Biometrics for Police Scotland manages the unit. As part of this assurance review, the Commissioner and his team visited the unit in Dundee on 7 November 2024.

The functions carried out by DNA Administration Unit staff include:

- aligning the sample to a subject and live proceedings on the Police Scotland Criminal History System (CHS)
- a DNA 'string' is added to CHS which updates the nominal page to reflect that DNA is held
- retention and weeding of samples

The Unit (or laboratory) may also reject samples for various quality assurance issues, e.g., inner sample bag not sealed, 2 swabs in one tube, wrong accused sample in wrong bag etc. In circumstances where the laboratory is unable to obtain a DNA profile from the buccal swabs and if the associated case then results in a conviction, the DNA Administration Unit will coordinate the request to the reporting officer to obtain a post-conviction sample within the 1-month timeframe provided by the Criminal Procedure (Scotland) Act 1995.

A question which arose during the Commissioner's visit to Dundee was in relation to the effectiveness and efficiency of having different administration arrangements in different locations for different biometric data types (DNA, fingerprints, CHS image). Whilst this question is beyond the published terms of reference for this assurance review, Police Scotland may wish to consider whether having different biometric data types administered by different administrative teams in different locations is the most effective and efficient way to exercise sound governance of biometric data arising from the same arrest episodes. An alternative approach might be for those siloed administrative arrangements to be centralised under the direction and control of the Police Scotland Head of Biometrics.

In the case of Criminal Justice DNA administration, the establishment of a centralised administration function has clearly strengthened elements of strategic governance and means that management information is collected and disseminated on submission volumes including statistical analysis of where samples are incorrectly packaged or labelled. In turn, this feeds the cycle of continuous improvement. As a corollary, and as will be discussed next, the strategic governance around evidential samples has room for significant improvement.

Evidential DNA sample journey

Evidential samples are taken where there is potential to include DNA evidence in the case or where the Procurator Fiscal (PF) may instruct a DNA examination after receipt of the Standard Prosecution Report (SPR). This includes where a suspect has previously been identified by means of a CJ DNA match. Failure to take an evidential sample may result in the PF having to apply to the court for a warrant to obtain the sample or result in critical forensic evidence being lost.

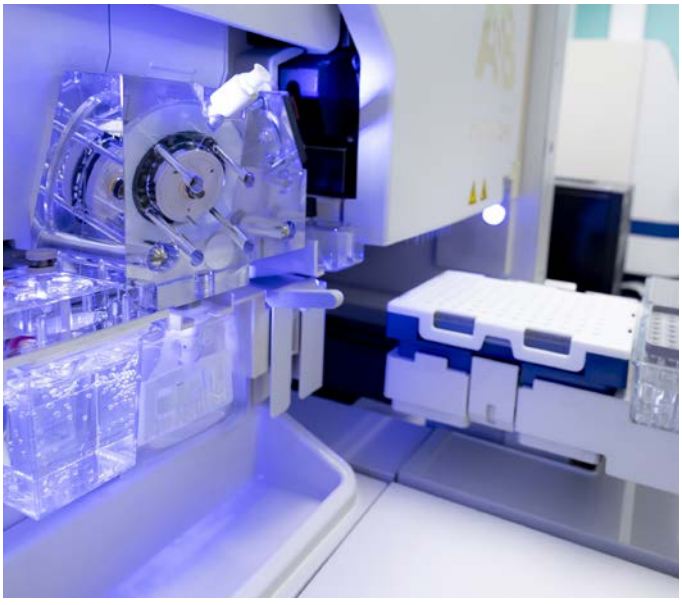
Evidential samples may be taken from an accused person by the investigating officer in the custody environment or at a potential crime scene or any other location. In addition to suspects or accused persons, evidential samples (and elimination samples) may also be taken from victims of crime and may be taken under different scenarios by the investigating officer or by a crime scene examiner, forensic scientist, forensic medical examiner or in the case of victims of sexual offences by a healthcare professional.

Consequently, evidential DNA samples are held at disparate locations throughout Scotland often in fridges (for example Criminal Investigations Department (CID), Response, Community or Roads Policing) or sometimes in local productions rooms or in centralised productions facilities and often for many months and sometimes years.

Sometimes evidential samples will be submitted successfully for DNA profiling and on some occasions the profiling request will be (correctly) rejected by the SPA Forensic Services Gateway who perform a triage service for laboratory demand management purposes.

Police Scotland enquiry officers dealing with evidential DNA should record the location of the samples within the UNIFI Productions module. UNIFI can produce management information and performance reports but it does not do so for productions and does not currently have the capability to do so for evidential DNA samples, or to apply retention rules for evidential DNA to the production's module.

By contrast, with the approach for CJ DNA administration, the strategic oversight arrangements for evidential DNA are problematic as there is no effective centralised oversight or control being exercised including of the weeding of evidential productions. Consequently, it was not possible to obtain management information in relation to the volumes of evidential DNA on retention at the point of conducting our fieldwork in November 2024.



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For those reasons, it is recommended that Police Scotland conduct a review of the administrative arrangements for evidential DNA swabs to ensure the effectiveness and efficiency of their management and to improve strategic governance and oversight. There is also a broader question to be asked in relation to why or whether it is even necessary for Police Scotland to sometimes take both CJ and Evidential samples in the same case resulting in 4 buccal mouth swabs being acquired and retained from an accused person. In the case of fingerprints, the same sample is used for both criminal justice and evidential purposes and, whether DNA or fingerprints, the power of acquisition comes from the Criminal Procedure (Scotland) Act 1995. It should be noted that no other UK police force takes 4 buccal swabs in this manner.

The Commissioner is aware of ongoing discussions between Police Scotland and the Crown Office and Procurator Fiscal Service (COPFS) on this matter but notes that taking and profiling half the number of samples would realise significant financial efficiency savings that could potentially be redirected into other areas that will be discussed later in this report. The cost of profiling a DNA sample ranges from £32 for a simple sample to around £79 for a complex sample requiring the involvement of a scientist.

Recommendation No. 3

Police Scotland should conduct a review of the administrative arrangements for the management of evidential DNA swabs to ensure the effectiveness and efficiency of their management and to improve strategic governance and oversight.

Strategic Governance of DNA and other biometrics

Police Scotland has a Biometrics Oversight Board which is responsible for the strategic governance of biometric data held by Police Scotland or held jointly with the SPA Forensic Services. The Force Biometrics Oversight Board was established in 2021 in response to the Parliament introducing the Scottish Biometrics Commissioner Act 2020. It was originally chaired by a Deputy Chief Constable and subsequently an Assistant Chief Constable with a Detective Chief Superintendent sometimes deputising. The terms of reference for the Board are that it should meet twice annually. However, at the point of our fieldwork in November 2024, there had not been a Biometrics Oversight Board since 7 December 2023 due to changes within Police Scotland executive command structures.

Not having a Biometrics Oversight Board meeting for nearly a whole calendar year delivering executive level direction and ensuring sufficient resource, helps to explain why at the time of our fieldwork, Police Scotland had made no progress on the development of a Biometrics Strategy that had been identified as an area for improvement from internal audit in 2023. The BDO internal audit of Biometrics was presented to the SPA Audit, Risk and Assurance Committee on 7 November 2023. The internal audit noted:

'…the Scottish Biometrics Commissioner's Code of Practice requires that strategies, standard operating procedures, and policies are in place for the acquisition, retention, use and destruction of biometric data and samples, and are regularly reviewed; however, our discussions with management noted that there is no overarching Strategy or Policy document across both Police Scotland and SPA Forensic Services.'

Scottish Police Authority
Biometrics Internal Audit Report
October 2023

The absence of a documented joint Police Scotland Biometrics and SPA strategy, vision, or plan at the time of our fieldwork in November 2024 meant that we found that Police Scotland still had no clear strategic roadmap setting out what it hopes to achieve with biometric data and technologies in the next three, five, or ten year period. Without such a strategy or plan, there are no guiding principles or rules that define the actions that Police Scotland should take (or not take) and the areas that should be prioritised (or not prioritised) to achieve the desired strategic outcomes.

The Commissioner would have expected such a strategy to be in place more than twelve months after it was identified as an area for improvement at SPA Audit, Risk and Assurance Committee and was disappointed to find that it was not. Without such as strategy or plan, there is no clear vision of what Police Scotland hopes to achieve with DNA, fingerprints, or facial images or other biometric enabled technologies including retrospective facial search. It also makes it difficult to have a meaningful national conversation on the potential adoption of emerging biometric technologies such as the Home Office Strategic Facial Matching Programme or other biometrics that could make an important public safety contribution such as Live Facial Recognition.

Having a clear strategy or plan and roadmap is an essential component of sound strategic governance and will help maintain public confidence and trust. Without Police Scotland firstly determining the operational strategy, it will not be possible for SPA Forensic Services to develop a supporting scientific strategy that meets the determined priorities of Police Scotland. Clearly, such a strategy (or documented vision or plan) should align to the Strategic Police Priorities for Scotland set by Scottish Ministers, the Police Scotland Three-year Business Plan to 2027 and the Police Scotland 2030 Vision. It should also set out a clear vision for each biometric data type including any required capital expenditure for example to roll out new biometric enabled technologies or to maintain or re-platform biometrics databases.

Given the lack of progress at the time of our fieldwork, the Commissioner now makes a formal recommendation for Police Scotland to accelerate the development of a documented plan setting out what Police Scotland hopes to achieve with biometric data and technologies in the next three, five, or ten-year period. The plan should be approved by the Force Executive and the Scottish Police Authority and should be in place by no later than 31 October 2025.

Recommendation No. 4

Police Scotland should accelerate the development of a documented strategy, setting out what it hopes to achieve with DNA and other biometric data and technologies in the next three, five, or ten-year period. The plan should be approved by the Force Executive and the Scottish Police Authority and be in place by no later than 31 October 2025.

DNA and Scottish Police Authority Forensic Services

The DNA sections of SPA Forensic Service provide four key services to Police Scotland, the PIRC, and other law enforcement agencies:

1. **Casework** – these are cases where there is a known accused and comparisons can be made between reference samples and a crime sample.
2. **Undetected cases** – these are where the police do not have a suspect and where the Scottish DNA database and UK National DNA Database are used to try to identify matches between a crime sample DNA profile and the profile of a person held on the database
3. **Criminal paternity testing** – in cases of rapes and incest etc.
4. **Identification of individuals** – missing persons, bodies, and body parts

The current DNA profiling method used for the Scottish DNA Database – known as DNA24 – analyses 22 areas of a person's DNA and two sex markers. The resulting DNA profile is then retained on the Scottish DNA database (a DNA 17 profile is sent for uploading to the UK DNA database) for the duration determined by current Police Scotland policy. Profiles retained on these databases will be routinely searched against unidentified profiles from unsolved crime scenes. The annual cost of providing DNA interpretation and analysis including consumables is around £2.1 million.

How DNA is extracted in the laboratory

In most cases the first stage in DNA profiling involves adding chemicals to burst open the cells, extract the DNA and isolate it from other components. In biology this process is known as lysis and refers to the breaking down of the cell membrane resulting in the release of cell contents. However, forensic scientists have various extraction methods available depending on the source material and type of investigation.

For example, in the case of sexual assault e.g. in cases involving a male and female it is common for male DNA within a mixed profile obtained (a sample containing DNA from more than one person) to be overwhelmed by the presence of the female donor of the intimate sample, therefore forensic scientists may deploy different forensic strategies, for example to split the intact sperm heads from the female epithelial DNA material so that the male DNA of a suspect or suspects is identifiable.

Once the DNA has been extracted the next stage is to determine how much DNA is present within the extracted sample. This is known as quantification. The following stage is to copy and build replicate strands of DNA, many times (known as amplification), using a chemical process called PCR (polymerase chain reaction) to obtain as much viable DNA as possible. The amplified DNA are separated by size, through a process known as capillary electrophoresis leading to the final stage of data analysis.

Figure 5. The scientific stages of obtaining a DNA profile from a CJ buccal swab.

In practice, forensic DNA profiling combines the scientific disciplines of anatomy, cell and molecular biology, genetics, mathematics and statistics. The chemical stability of DNA is useful for forensic science because it means that DNA can be derived from a biological sample and analysed long after it was deposited at or recovered from a crime scene. If evidential materials (productions) potentially containing DNA are stored in the correct conditions, and as witnessed through many cold case investigations in Scotland and elsewhere, DNA can often be recovered many decades later using advances in DNA location, interpretation, and analysis technologies that were simply not available when the original crime was committed. However, DNA is not stable forever and can be degraded or contaminated.

The scientific processes involved in profiling a criminal justice sample from a buccal mouth swab are conducted by SPA Forensic Services. Most of those scientific processes are automated and are conducted by laboratory robots in a sterile environment.

During a visit to SPA Forensic Services laboratory in Dundee the Commissioner was given a walkthrough of the different scientific stages. The main stages involved in obtaining a DNA profile from a CJ buccal swab are illustrated in figure 5, above.

The basic process for obtaining an evidential DNA reference profile is the same. However, in the case of biological materials recovered from a crime scene there is an initial purification stage to remove any contaminants that may be present. This involves the use of polymer coated magnetic particles that cause the DNA to bind to the polymer. This is followed by lysate separation and washing by removing the DNA with a magnet. However, it should be noted that there are various other scientific techniques which may be deployed in DNA analysis in accordance with the nuances of a particular investigation and different scientific techniques where it is suspected that a sample may contain DNA from multiple sources, for example in the investigation of sexual offences. Otherwise, the generic process is illustrated overleaf, see figure 6.

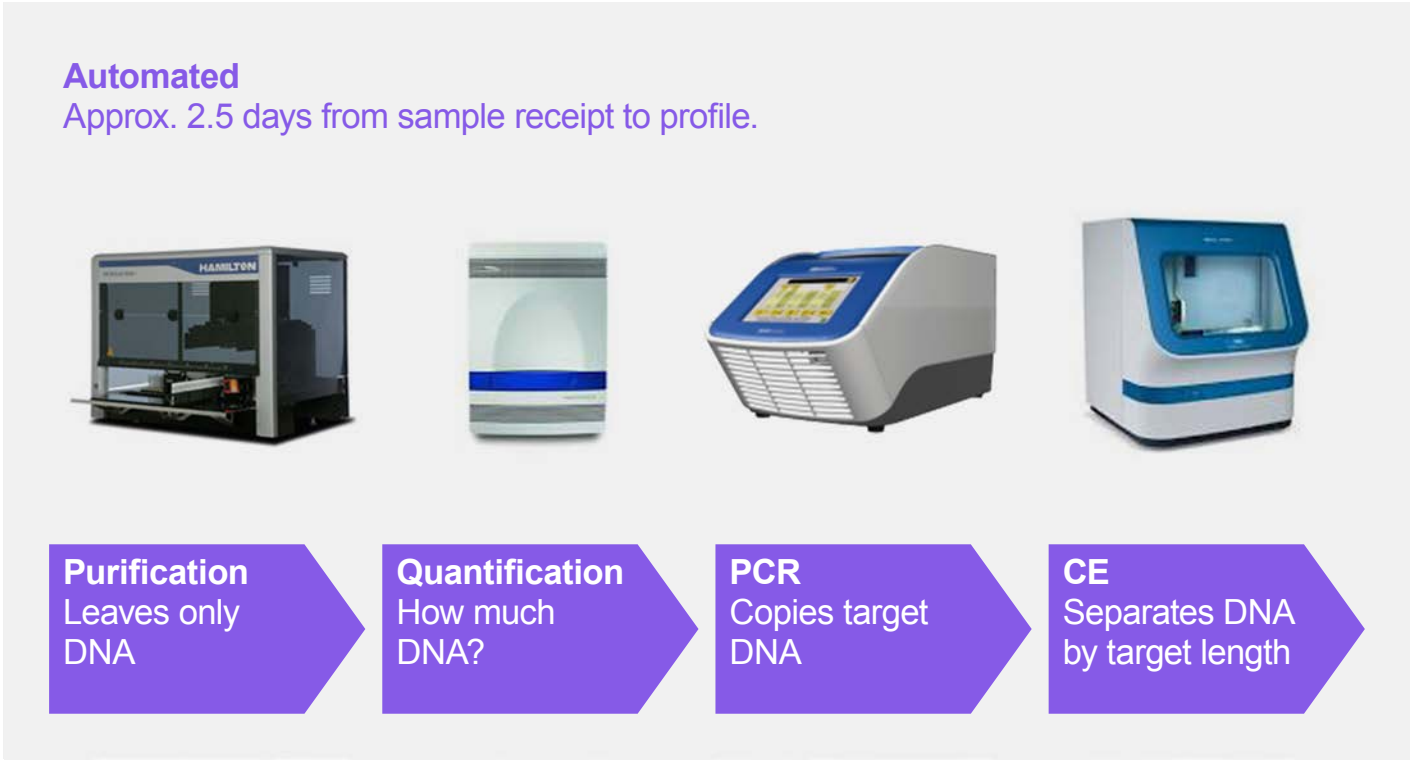


Figure 6. The scientific stages of obtaining a DNA profile from a crime scene

As can be seen, many of the laboratory processes are automated with 'robots' conducting many of the scientific processes. Most of these robots are now about 11 years old and will need replaced in the next two to three years as they reach the end of their serviceable lifespan and will require capital investment for an asset refresh.

DNA profiling from samples recovered from crime scenes are searched against the Scottish DNA database and if a match is found a report is generated to Police Scotland for further action and investigation. If no match is found at that time, then the relevant profile is retained on the Scottish DNA Database and is also placed on NDNAD. This gives all UK police forces the ability to search against crime scene profiles and is helpful when dealing with criminals who travel extensively to evade justice and commit crime in different jurisdictions.

The exception to this is profiles taken from volunteers for the purpose of intelligence-led screens.[14] These samples are only compared against the crime scene profile in question and destroyed on conclusion of the investigation or, subject to any evidential requirement, if the volunteer withdraws their consent to retention. In the case of persons arrested in Scotland by UK-wide policing bodies[15] the biometric data is captured when the subject is processed at a Police Scotland custody facility. However, in these cases the DNA mouth swabs are not sent to SPA Forensic Services for forensic profiling but instead are sent to accredited scientific laboratories in England. From there, the relevant DNA profile will be uploaded to NDNAD.

SPA Forensic Services profiling does not examine all DNA variations between individuals. Instead, the technique is designed to target the non-coding areas of DNA that are known to differ widely between individuals.

[14] Colin Pitchfork – The Forensics Library, aboutforensics.co.uk.
[15] National Crime Agency, British Transport Police, Ministry of Defence Police.

Other than sex, the areas of DNA targeted by Forensic Services profiling do not contain information that could be attributed to physical characteristics – such as eye colour – or enable definitive determination of medical conditions. It is possible to identify a person very precisely, but the DNA area used to show a match (sometimes referred to colloquially by scientists as Junk DNA[16]) contains no genetic characteristic information.

In seeking to compare DNA recovered at a crime scene with a CJ profile or vice versa, profiles are compared using the individual components of a DNA profile known as "alleles". There is a minimum number of components that must be identical to consider the information to be a reliable match. A match report is issued when two or more profiles loaded to the database have identical DNA profiles. This can be a person's DNA matching an undetected crime scene stain, or two undetected crime scene profiles matching each other, or a crime scene sample matching to an existing criminal justice profile.

DNA profiles on SDNAD and NDNAD makes it possible to compare a DNA profile from a person, known as a reference sample, with a DNA profile from a 'crime' sample, for example, from the scene of a known crime. If there is a full match between the DNA profile from the person and that of the crime sample, it can be stated in terms of probability. For example, if a good quality DNA sample is found, it is estimated that this result is greater than one billion times more likely if the DNA was from person A rather than another individual unrelated to them. This explains why DNA has become so important in criminal investigations as it can be used to exclude an individual as a source of DNA or to contribute to prosecution evidence.

The scientific methods deployed by SPA Forensic Services in relation to DNA are independently validated and accredited to international standard ISO/IEC 17025:2017 by the United Kingdom Accreditation Service (UKAS). The relevant laboratories and scientific techniques covered can be viewed on the UKAS Schedule of Accreditation for the SPA Forensic Services issued to SPA Forensic Services on 02 July 2024. During our review, it was apparent that the SPA Forensic Services, the largest public sector provider of forensic services in Europe, continues to provide a world leading value for money forensic service in relation to DNA. Through its use of DNA24, SPA Forensic Services provides Police Scotland and other criminal justice partners a highly advanced DNA interpretation and analysis capability. It is of a higher standard than that used by most other police forces in the UK, Europe and worldwide. At present, SPA Forensic Services has no plans to move beyond DNA24 due to the high sensitivity of the technique and the discriminatory results it provides.

As DNA technology continues to improve, the two biggest drives for developments in forensic DNA profiling are firstly the use of 'robots' to improve bulk sample throughput by automation of the sample extraction, quantification, amplification, analysis and interpretation or searching against the available databases. Secondly, to improve the sensitivity of testing so that DNA can be successfully recovered from smaller and poorer quality source biological materials, or from mixed samples as previously described.

[16] In 1972 the late geneticist Susumu Ohno coined the term "junk DNA" to describe all noncoding sections of a genome, most of which consist of repeated segments scattered randomly throughout the genome.

Scottish DNA Database (SDNAD)

Police Scotland and SPA Forensic Services jointly maintain the Scottish DNA database (SDNAD) which was established in 1996, prior to police reform in Scotland, meaning that the database is now almost 30 years old. During our review it became apparent that the administration and weeding from the Scottish DNA database is still a labour-intensive process with a consequential impact on effectiveness and efficiency and that it also has limitations in terms of integration to other systems and limited management information. Because the database system is so old, it was also not designed to produce comprehensive management information to meet modern policing and societal expectations such as recording the ethnicity of data subjects. In the medium to longer term, a new solution will be required to facilitate end-to-end automation for routine transactions, ensuring a more responsive service and delivering greater business efficiency.

A key consideration in this regard is under investment in police capital budgets, and as a consequence funding available for SPA Forensic Services, since police and fire reform in Scotland in 2013 which in turn translate into under-provision of important technologies and problems with capital asset refresh. This is a theme that the Commissioner and HM Chief Inspector of Constabulary in Scotland have previously highlighted in their respective submissions to the Scottish Parliament Justice Committee in 2024 as part of its pre-budget scrutiny.[17]

In June 2020, a report entitled 'Home Office Biometrics Programme: Implications and future options for biometric data and biometric policing databases in Scotland' was submitted by the then SPA Director of Forensic Services to Scottish Government and SPA Forensic Services Committee.[18] The report recommended that SDNAD should be re-platformed as soon as reasonably practical to a solution delivering automation of routine transactions including a more automated interface with NDNAD. The 2020 report was subsequently referenced in an update paper from the then SPA Director of Forensic Services to SPA Forensic Services Committee on 19 April 2021. Accordingly, the question of replacing or upgrading SDNAD has been high on the SPA Forensic Services agenda since at least 2021.

From discussions with SPA Forensic Services senior management, significant financial investment will need to be found in the medium term to address an ageing DNA database in Scotland. SPA Forensic Services are currently considering options including a core SPA Forensic Services infrastructure solution that hosts and manages all scientific functions through a modular portal including DNA either as part of the core solution or as an orbit system. Having a whole-systems core solution would enhance the Crime Scene to Court model in Scotland (see Appendix A) and would improve speed and coordination across the entire forensic and criminal justice process. Continued capital investment in forensic science in Scotland, including the delivery of a core solution, would also provide considerable downstream benefits across the justice system including efficiencies and improved outcomes.

[17] Commissioner submits call for evidence to Parliaments Criminal Justice Committee, 7 September 2023, Response 257126196 to Criminal Justice Pre-Budget scrutiny: 2024-25 – Scottish Parliament – Citizen Space

[18] Unpublished report

However, it is possible that such a solution may rely on hyperscale Cloud processing and accordingly, there may be questions as to whether significant departures from the EU Legislation will affect the Part 3 adequacy agreement with Europe. In this regard it is important to note that DNA sometimes constitutes 'genetic data' in UK data protection law and in terms of the Scottish Biometrics Commissioners' Code of Practice must be afforded the highest levels of protection from unauthorised access or unauthorised disclosure. Some of these issues may be clarified by the forthcoming UK Data (Use and Access) Bill. However, it is clear from our review that SDNAD needs replacement or upgrading in the medium term. Accordingly, it is recommended that in the medium term from 2026 to 2031, SPA Forensic Services should seek capital funding to deliver a whole-system core operating solution for Forensic Services that either includes the Scottish DNA Database within the core system or as an orbit system to enhance the effectiveness and efficiency of the Crime Scene to Court model in Scotland.

Recommendation No. 5

In the medium term from 2026 to 2031, SPA Forensic Services should seek capital funding to deliver a whole-system core operating solution for Forensic Services that either includes the Scottish DNA Database within the core system or as an orbit system to enhance the effectiveness and efficiency of the Crime Scene to Court model in Scotland.

Guide to further reading and other oversight bodies

A brief non-technical guide to the use of DNA and other types of biometric data can be found on the Scottish Biometrics Commissioner website. The Guide to Biometrics in Policing and Criminal Justice has a read time of around five minutes. An Easy Guide to Verification vs Identification on the use of biometric data and technologies used in UK policing can also be found on the website with a read time of two minutes. The Scottish Biometrics Commissioner website also hosts a copy of the Police Scotland information leaflet given to persons in custody who have biometric data captured: Your photograph, fingerprints and DNA: what we do with them which also has a read time of around two minutes. Police Scotland has also published an Easy Read version of the information leaflet.

DNA and other types of biometric data are of course used extensively within the entire criminal justice ecosystem in Scotland. However, the functions of the Commissioner are restricted to Police Scotland, the Scottish Police Authority, and the Police Investigations and Review Commissioner. Accordingly, this joint review does not explore issues such as the subsequent leading of DNA evidence in Scottish courts as the use of such data by other criminal justice partners including in the prosecution of crimes and offences by the Crown, is beyond jurisdiction. The role of scrutinising Scotland's prosecution service is within the statutory responsibilities of HM Chief Inspector of Prosecution in Scotland.

A Forensic DNA Analysis: a primer for courts, produced by the Royal Society and the Royal Society of Edinburgh serves as a helpful and comprehensive guide to assist the judiciary in their understanding of DNA and may also be of interest to readers. The production of the judicial primer was led by Lady Justice Rafferty DBE with significant contribution from Professor Niamh Nic Daéid. Professor Nic Daéid is the Director of the Leverhulme Institute of Forensic Science at the University of Dundee. She is also a member of the Scottish Biometrics Commissioner's Advisory Group and is also a member of the Biometrics and Forensics Ethics Group (BFEG) giving advice to the UK Home Office.

The acquisition, retention, use and destruction of biometric data such as DNA by Police Scotland, the Scottish Police Authority, and the Police Investigations and Review Commissioners subject to the provisions of the Scottish Biometrics Commissioner Act 2020, the oversight of the Commissioner and to the statutory Code of Practice prepared by the Commissioner and approved by the Scottish Parliament in November 2022. In the case of the 2020 Act in Scotland, the definition of biometric data extends not only to the computerised DNA profile, but also to the source biological materials from which such a record may be created.

It should also be noted that DNA is sometimes classed as 'Genetic Data' in UK Data Protection law and in such circumstances also falls under the UK-wide oversight of the UK Information Commissioner (ICO). However, genetic analysis data is only personal data (and so genetic data) under UK GDPR if you can link it back to an identifiable individual. Therefore, UK data protection laws would not apply to the source biological materials or to any unsolved crime scene profiles which have not yet been attributed to an identifiable individual. It should also be noted that UK data protection law is intended to protect the information rights of living individuals. Therefore, the significant volumes of DNA materials held by the police relating to deceased persons although within the scope of the Scottish Biometrics Commissioner Act 2020, are beyond the scope of UK data protection law.

Similarly, it should be noted that Scotland does not have a Forensic Science Regulator as exists on a statutory basis in England and Wales. It should also be noted that responsibility for independent oversight of the delivery of forensic services per se to Police Scotland by the Scottish Police Authority is within the statutory functions of HM Chief Inspector of Constabulary in Scotland (HMICS). Accordingly, this assurance review does not extend to matters beyond the acquisition, retention, use and destruction of DNA.

Although the devolved laws of Scotland and reserved UK legislation exist for entirely different legal purposes, they also provide important layers of independent oversight. In so doing, they protect the rights of data subjects and help to support the lawful, effective, and ethical use of DNA in a law enforcement context, thus helping to maintain public confidence and trust.

Findings
ii. The extent of the use of DNA in Policing in Scotland

Overview
This second findings chapter engages with the 'extent' of the use of DNA in policing in Scotland by:

- Introducing the Scottish DNA Database (SDNAD) and interfaces to the UK National DNA Database (NDNAD).
- Examining the types of DNA samples held.
- Considering the Police Scotland DNA Confirmed (DNAC) policy.
- Exploring the sex, age, and ethnicity of persons held on SDNAD.
- Revealing the extent to which DNA helps to solve crimes in Scotland.
- Reporting on crime scene match rates by crime and offence type.
- Explaining types of DNA searches conducted.
- Providing an overview of UK and EU exchange mechanisms for DNA.
- Exploring the use of DNA in missing persons investigations and the protection of vulnerable people.
- Considering sample error rates and laboratory accreditation.

The Scottish DNA Database (SDNAD) Volumes
On 31 March 2024, the Scottish DNA Database holds a DNA profile for 397,911 individuals. There were also 20,726 crime scene profiles not yet matched to an individual giving an overall total of 418,637. The number of individual profiles held is equivalent to 7.29% of the population of Scotland.[19] However, it should be noted that SDNAD will contain the profiles of travelling criminals and foreign nationals who have offended in Scotland. In 2023/24, 15,209 Criminal Justice DNA profiles were added to SDNAD and 7,537 were removed.[20]

DNA

[19] Based on 2019 Census data showing population of Scotland as 5.454 million people
[20] Scottish Police Authority Forensic Services Annual Review 2023/24.

DNA Database	Subject profiles Number held at 31.3.24	Crime scene profiles Number held at 31.3.24	Total
Scotland	397,911	20,726	418,637
UK	7,226,795	688,054	7,914,849

Figure 7. Number of subject and crime scene profiles retained in Scotland and UK on 31 March 2024

The exponential growth of SDNAD between 2004 and 2023 is illustrated by figure 8. What figure 8 illustrates is that in 2004 there were 163,459 Criminal Justice profiles (people) on SDNAD. Because new profiles are added more quickly than those removed, by 2023 the number of Criminal Justice profiles (people) had risen to 378,779, and by 31 March 2024 it had grown to 397,911 people.

Therefore, over the 20-year period, SDNAD had grown with the addition of the DNA profiles of 234,452 people meaning that the number of DNA profiles on retention has grown by 69.7% over that period.

If this trajectory was to continue, and unless Police Scotland changes its retention policy, then by 2044, Police Scotland might have 674,697 profiles on retention. As highlighted in the joint Scottish Biometrics Commissioner and Scottish Government review of the laws of retention in Scotland published in October 2024, there is little in the way of police management information to justify the need for the extraordinarily long retention periods currently in place, or indeed in terms of properly evaluating its value to policing. The growth of SDNAD between 2004 and 2023 is illustrated by the following bar chart:

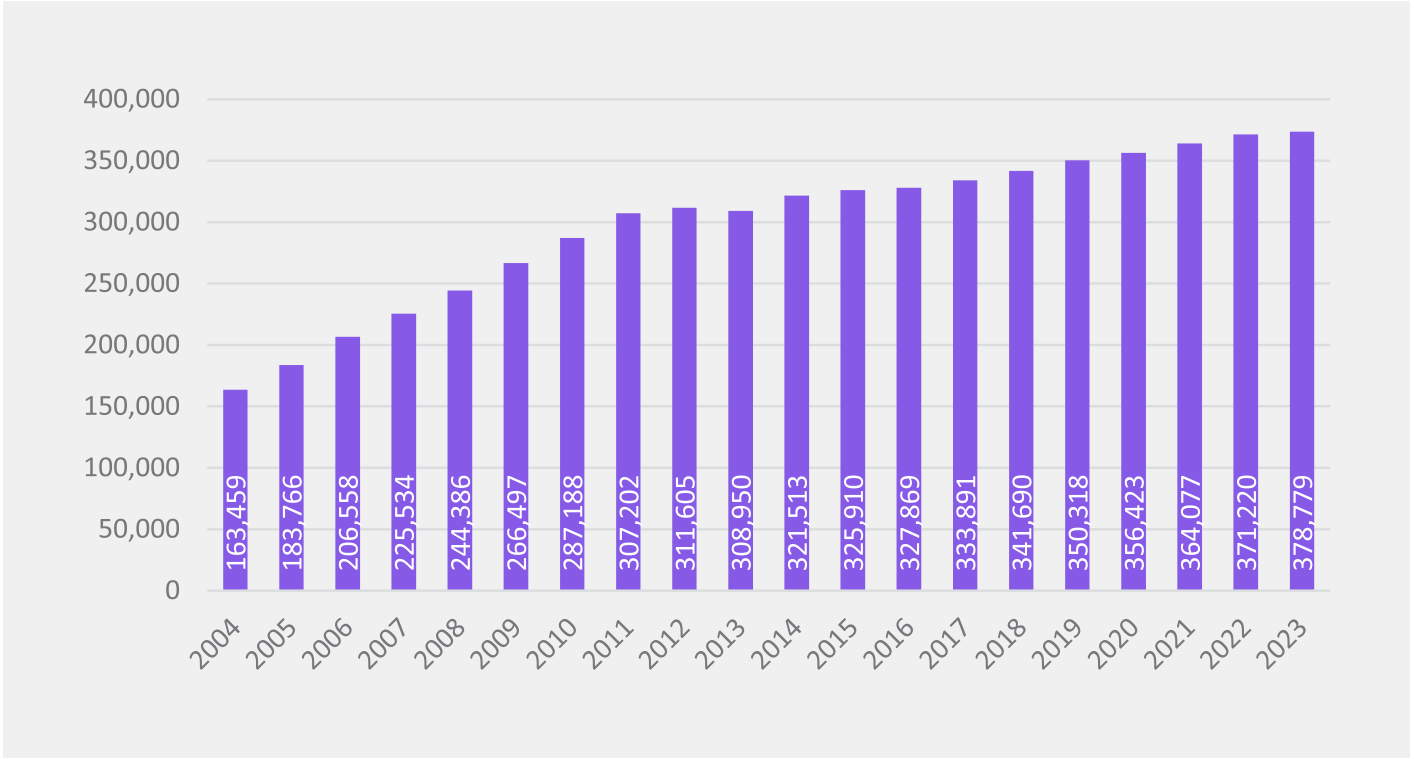


Figure 8. Number of Criminal Justice subject DNA held on SDNAD 2004 to 2023: Source: Police Scotland

Since its establishment in 1994, the scientific techniques deployed in DNA profiling have advanced significantly. Before 1995, only 4 STR loci were analysed. From 1995 it advanced to 6. Between 1999 and 2014, 11 STR loci and a sex marker were analysed. In 2014, and shortly after the establishment of Police Scotland and Scottish Police Authority, Scottish Government invested £6 million in new DNA interpretation and analysis technology within SPA Forensic Services laboratory at the Scottish Crime Campus. The new profiling technology (DNA24) analysed 22 STR loci and 2 sex markers. The DNA technology investment was widely reported in the media as being the most advanced in Europe.[21]

To maximise the business benefits of more advanced DNA interpretation and analysis capability, there was an opportunity at that juncture for older DNA samples to be re-profiled to the higher standard using the second unused vials kept on long-term retention. However as more than 250,000 samples were on SDNAD at that time, a decision was taken on the grounds of both cost and laboratory capacity not to do any bulk back record conversion as it would have cost more than £10 million to do so. That decision is understood.

However, a joint decision appears to have been taken by Police Scotland and the SPA Forensic Services not subsequently take a new DNA24 CJ sample where an older SGM+ sample was already held. This means that over the past decade, recidivist offenders, including those arrested on multiple occasions have not had a more advanced DNA sample taken whereas persons arrested for the first time have a DNA24 profile captured. This helps to explain why more than a decade after its introduction, 69.9% of the DNA profiles in the Scottish DNA Database are less discriminatory than DNA24.

The scientific advice that the Commissioner received from SPA Forensic Services is that this is unlikely to have resulted in any crimes going undetected, however the scientific advice was also that having more criminal justice profiles as DNA24 would reduce the number of adventitious matches leading to more efficient and effective investigations.

[21] Advanced DNA in use at Scottish Crime Campus, BBC News, 25 February 2015.

Years used	**Number of STRs analysed**	**The commercial kits (multiplexes)** used for the analysis of groups of STRs present at different loci	**Numbers of profiles** by type held within SDNAD on 7/11/24
Pre 1995	4	Quadruplex amplification system	None
1995	6	SGM (second generation multiplex)	12,073
1999 to 2014	11	SGM +	255,687
2014 to present	23	AmpFISTR (known as DNA24)	115,630
Note. DNA profiles are added and weeded daily. The figure of 383,390 profiles is a snapshot taken on 7 November 2024 on a visit by the Commissioner to the Police Scotland DNA Administration Unit in Dundee. The 383,390 profiles related to 379,713 people meaning that 3,677 records (0.95%) were duplicate records held on the system.			**383,390 Total**

Figure 9. DNA profiles within Scottish DNA Database by type and volume on 7 November 2024

Figure 9, above, illustrates the evolution of DNA in Scotland.

As indicated in the note to the foregoing table, around 0.95% of DNA profiles held within SDNAD are duplicates which were already within the database before Police Scotland established the DNA Administration Unit in Dundee. By comparison, the FINDS Annual Report for 2023/24 reported that approximately 17% (1.2 million) of the 7,226,795 DNA profiles within NDNAD were duplicates. Having duplicate profiles within any law enforcement DNA database does not impact on match rates but it does say something about the effectiveness of governance arrangements and weeding regimes.

Recommendation No. 6

Police Scotland and the SPA Forensic Services should review the current DNA Confirmed (DNAC) policy against the context of scientific advice highlighting that having more Criminal Justice profiles as DNA24 would reduce adventitious matches leading to more effective and efficient investigations by more speedily eliminating innocent suspects from police investigations.

Against the context of this recommendation, it is also important to remember that DNA has an important exculpatory (elimination) value which although significant is not measured anywhere and therefore does not feature in any official statistics. Therefore, using more advanced DNA in investigations will also help to eliminate innocent people more quickly.

Sex of people on SDNAD

Most subject profile records held on SDNAD come from people who have been arrested for an offence in Scotland, so the composition is different from that of the general population. For example, less than half the Scottish population is male, but most DNA profile records on SDNAD belong to men, because the majority of those who offend and who are arrested are male.

On 31 December 2023 there were 378,779 profiles on the SDNAD. 313,404 of these profiles related to males, and 65,375 were females. It should also be noted that in the case of DNA, the sex of the subject is based on biological sex. This means that 82.75% of Criminal Justice Profiles held within SDNAD on 31 December 2023 were persons who are biologically male.

Age of people on SDNAD at time when DNA taken

Most subject profile records held on SDNAD relate to people who were aged 18 to 30 years when their DNA was captured as part of criminal justice processing following arrest. The next most significant group is people who were aged 31 to 45 years. Collectively, these two age groups represent 71.49% of all records held. The age of criminal responsibility in Scotland is twelve years of age. SDNAD contains the DNA profiles of twenty persons who were twelve years of age at the point when their DNA was captured and 36,890 persons who were aged thirteen to seventeen years old at the point when their DNA was captured. This means that SDNAD contains the profiles of 36,910 people who were children at the point that their DNA was taken. Therefore, people who were children at the time of their initial index offence leading to capture of their DNA is equivalent to 9.74% of the total number of profiles in SDNAD.

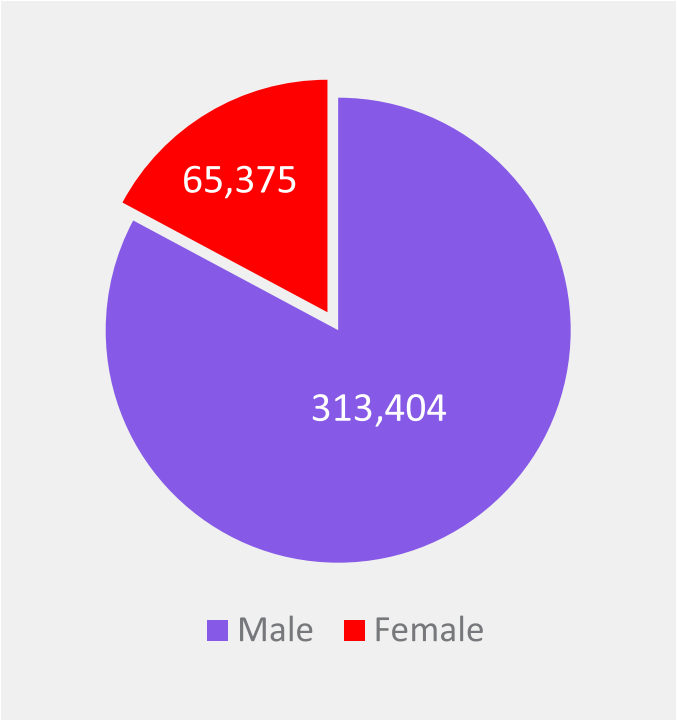


Figure 10. Sex of criminal Justice profiles on SDNAD at 31.12.2023 (82.75% male). Source: Police Scotland

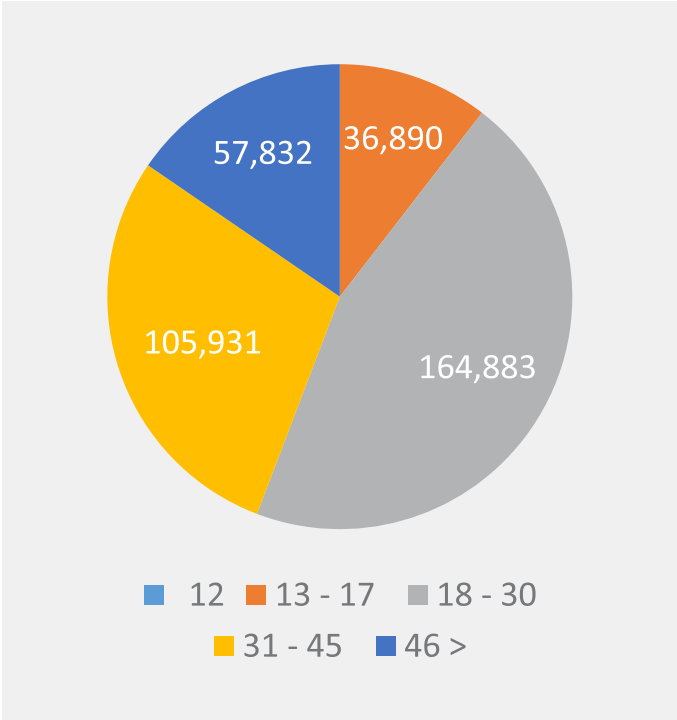


Figure 11. Age of persons on SDNAD at the time DNA taken. Source: Police Scotland

Ethnicity of profiles in SDNAD

The Equality Act 2010 (Specific Duties) (Scotland) Regulations 2012 as amended, apply to Scottish public authorities listed in the Schedule to the Act including the Chief Constable of Police Scotland and the Scottish Police Authority. Listed authorities who are subject to the Scottish specific duties are required to do several things including to assess and review the equality impact of policies and practices. It is against the law to discriminate against someone because of a protected characteristic.

During our fieldwork, Police Scotland were unable to provide us with any management information on the ethnicity of persons held within SDNAD as the database does not record this information. In the absence of such data being recorded on SDNAD, Police Scotland were instead asked to provide ethnicity data from 2023 to 2024 arrest episodes where DNA was taken, as ethnicity is a mandatory field in the Police Scotland National Custody System. However, the data extract obtained by Police Scotland was incomplete and was also so heavily caveated to render it unreliable for our purposes.

The fact that Police Scotland are failing to properly record and publish data on the ethnicity of arrested persons is concerning, against the context of the former and current Chief Constables having stated publicly that issues of institutional racism persist within Police Scotland.[22] Accordingly, we have been unable to establish whether there is any over-representation on the grounds of ethnicity or any other protected characteristic in Scotland. This against the context of official data showing that Black citizens are significantly over-represented in NDNAD.

It also mirrors more general concerns about such failings within UK policing.[23] Accordingly, it is recommended that Police Scotland should review its procedures for recording the ethnicity of persons who have biometric data held on SDNAD following arrest with a view to properly recording and publishing such data in support of equality duties and to promote public confidence and trust.

Recommendation No. 7

Police Scotland should review its procedures for recording the ethnicity of persons who have biometric data held on SDNAD following arrest with a view to properly recording and publishing such data in support of equality duties and to promote public confidence and trust.

[22] Police Scotland Chief says Force is institutionally racist, BBC News, 25 May 2023.
[23] Police forces still failing to record and publish data on ethnicity, HMICFRS, August 2023.

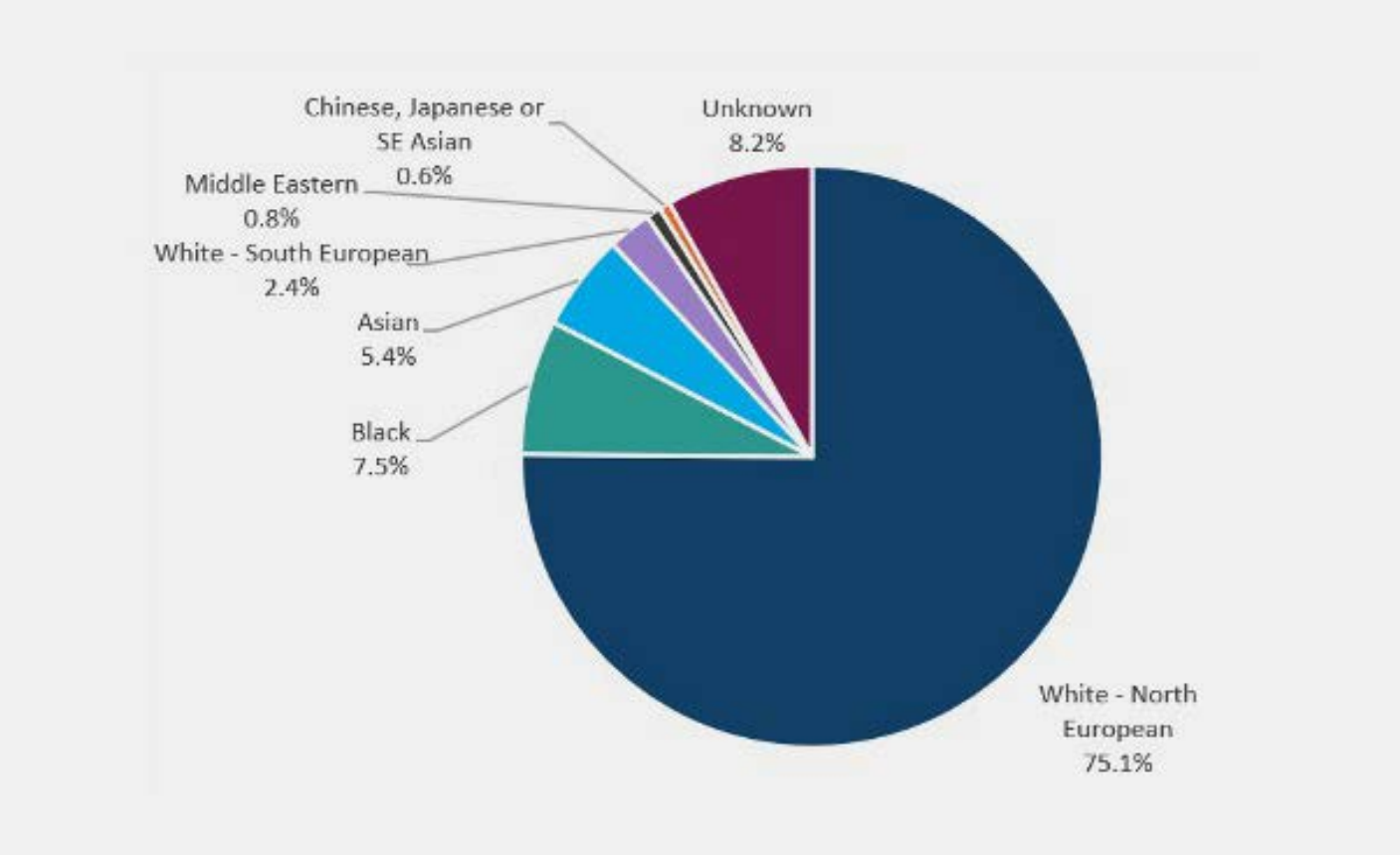
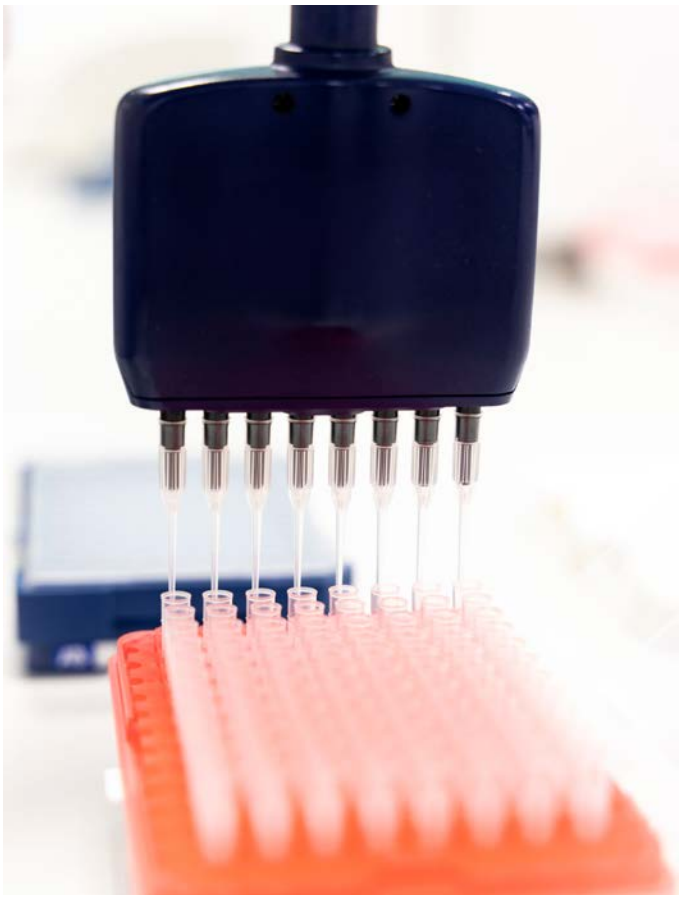


Figure 12. Sampling officer inferred ethnicity of subjects within NDNAD. Source FINDS.

Ethnicity of profiles in NDNAD

Looking at the UK, available data from NDNAD suggests that White-North Europeans make up 75% of all profiles held. 7.5% are recorded as relating to people with black skin and 5.4% of Asian heritage. According to the 2021/22 Census, around 4% of the UK population in 2021 were black. According to the Scottish Census data published in 2022, only 1.3% of the Scottish population were of black heritage. This confirms that people with black skin are significantly over-represented in the criminal justice system in England and Wales and consequently in the UK NDNAD, whilst other groups are underrepresented. The ethnicity of persons held on NDNAD on 31 March 2024 is illustrated in figure 12, above.



Forensic Labs 4

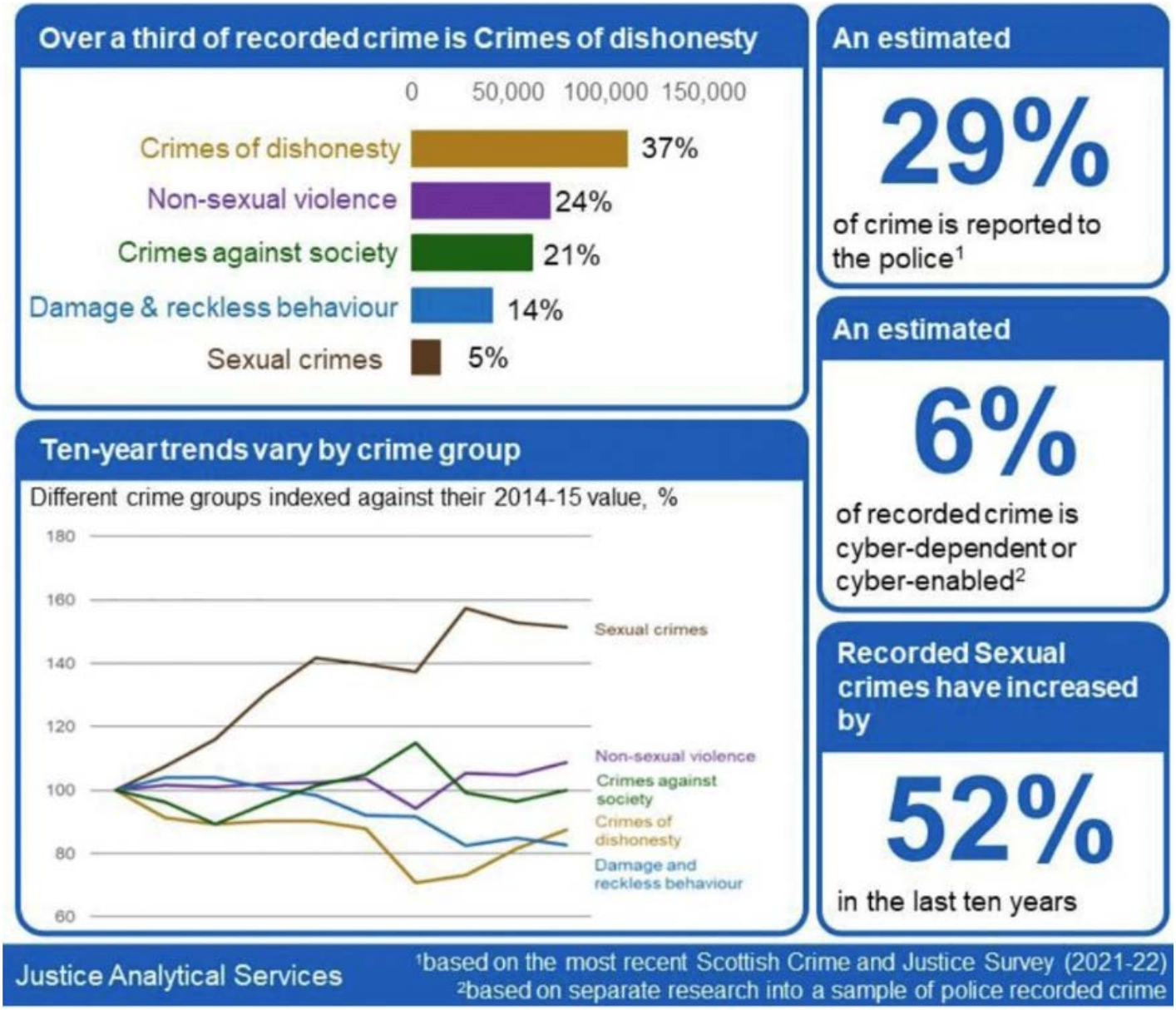


Figure 13. Recorded Crime in Scotland 2023-24: Source Scottish Government Justice Analytical Services.

How many crimes does SDNAD help solve?

In 2023 to 2024 there were 299,780 crimes recorded by Police Scotland.[24] As illustrated by the following extract from the official statistics an estimated 71% of crime is never reported to the police. Although long term crime levels are down in Scotland, the official statistics illustrate a worrying increase in sexual crimes.

SDNAD matches crime scene DNA profile records against subject DNA profile records and other crime scene DNA profile records, providing the police with invaluable information that helps them to identify possible suspects and solve crimes (albeit that a DNA profile match in itself is not usually sufficient to secure a conviction, so not every DNA profile match will lead to a crime being solved and in turn a successful conviction). Accordingly, it is impossible to say how many crimes DNA only helps to solve.

[24] Recorded Crime in Scotland 2023-24 official statistics published 25 June 2024.

Most crime in Scotland (and the UK) that is reported to the police does not have a forensic component meaning that quantitatively DNA does not play a statistically significant role in most police investigations or in contributing to overall crime solvency. For example, in 2023/24 there were more than seven million crimes recorded by the police in the UK with 20,881 recovered crimes scene DNA profiles matching to an existing record. This means that the percentage of all recorded crime in the UK with a DNA match was only 0.34%.[25]

In Scotland, there were 299,780 recorded crimes in 2023/24. During this period the number of new CJ Profiles added that matched to an existing Crime Scene profile was 213. In the same period there were 811 new crime scene profiles that matched to an existing CJ Profile. There were also 28 unidentified Crime Scene profiles matching another unidentified Crime Scene Profile. Therefore, the total number of matches from criminal justice sample to crime scene and vice versa was 1,024. When this figure is expressed against the volume of all recorded crime, it means that DNA provided a potential investigative lead in 0.34% of all recorded crime in Scotland in 2023 to 2024. A DNA hit though does not show that the subject of the match is the offender as there are many reasons why the DNA of an individual may be found at a crime scene. DNA can also be transferred directly or indirectly and issues of persistence of the deposited material may complicate the interpretation of evidence.

However, where a more serious crime scene is submitted for forensic examination in Scotland, and where DNA is recovered, then DNA recovered from such a crime scene in 2023/24 matched to an existing record at a match rate of 57%. Despite having a more advanced DNA interpretation and analysis capability, England and Wales had a significantly higher match rate at 64.8%.

The main reason for this is that the volume of DNA held in England and Wales where a higher population and higher percentage of citizens have been arrested by the police because of higher crime rates. Having more citizens on a CJ DNA database inevitably means more matches.

Crime or offence type

The following chart, figure 14, illustrates a breakdown of crime scene matches in Scotland by Scottish Crime Recording Standards (SCRS) offence group between 2011 and 31 March 2024. In that thirteen-year period there have been a total of 12,717 matches.

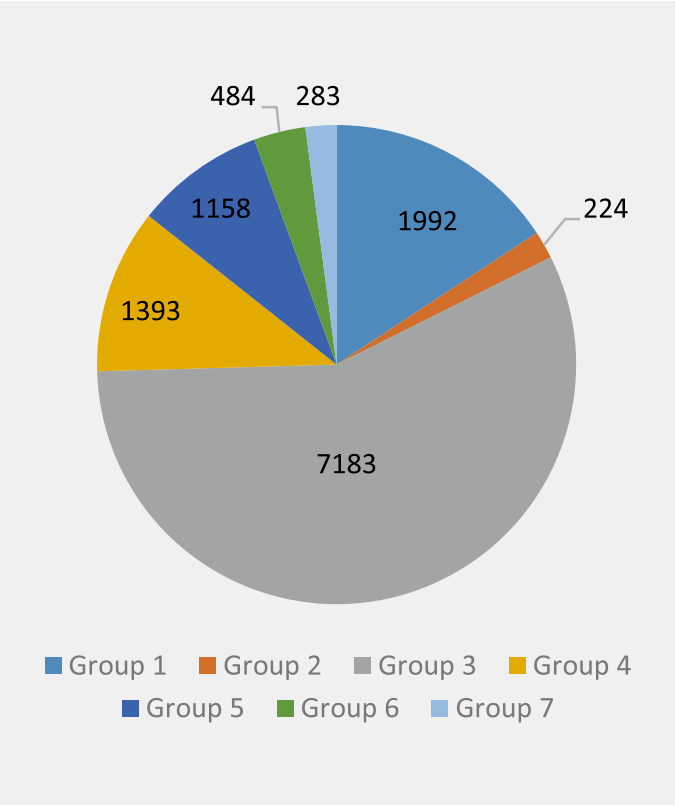


Figure 14. Crime scene matches by crime or offence in Scotland 2011/24: Source: Police Scotland

[25] Source, Office of National Statistics (ONS)

Crime in Scotland is recorded in specific categories, known as crime groups, namely:

Group	Description	Includes:
1	Non-sexual crimes of violence	Murder; attempted murder; serious assault; robbery; cruelty to children; threats and extortion
2	Crimes of indecency	Rape; indecent assault; lewd & libidinous practices; sexual offences
3	Crimes of dishonesty	Theft; housebreaking; theft of and from motor vehicles; fraud
4	Fire & malicious damage	Vandalism; malicious mischief; fire-raising; reckless conduct
4	Other crimes	Drug offences, carrying offensive weapon (including knives); bail offences; crimes against justice (e.g. Perjury)
4	Miscellaneous offences	Breach of the peace; petty assault; racially aggravated conduct or harassment; alcohol related offences
7	Road traffic offences	Dangerous and careless driving; drink/drug driving; speeding; vehicle defect offences

Figure 15. Crime Groups categories

Volunteer DNA

As indicated earlier in the report, The Criminal Justice (Scotland) Act 2003, Section 56, facilitates the taking of DNA samples for recording on the Volunteer DNA database. During 2023/24, Police Scotland uploaded 11 volunteer DNA profiles to SDNAD. In all 11 instances, the profile matched to a previously unsolved crime scene.

Retention periods for DNA

As previously discussed, Police Scotland policy is to retain a person's DNA until at least their 100th birthday or three years after death whichever comes sooner. This was the subject of a recommendation from the Commissioner and Scottish Government in the joint review of the laws of retention in Scotland laid before the Scottish Parliament on 31 October 2024.

Types of DNA Searches

1. Routine Searches

Criminal justice or crime scene DNA profile records are loaded to both SDNAD and NDNAD for routine searching. SDNAD uses 22 DNA markers plus two sex markers, whereas NDNAD uses 16 DNA markers plus a sex marker. Routine matches are made from DNA profile records loaded to both SDNAD and NDNAD. This ensures that police records can be contrasted and compared from throughout the UK.

2. Non-Routine Searches

For a crime scene DNA profile to be uploaded to the UK NDNAD, it must consist of a minimum of four pairs[26] of numbers and a sex marker, and it must be a full profile for subject profile records. Where this criterion is not met, for crime scene DNA records, it is nonetheless possible to carry out a non-routine search of NDNAD. Further details can be found in the Forensic Information Databases Service (FINDS) Annual Report for 2023 to 2024.

[26] Amelogenin locus (Biological sex marker) plus a minimum of both alleles in four of the six SGM loci (vWA, D8, D21, THO1, D18 and FGA), of which at least one must be a highly discriminating loci (i.e. FGA, D21 and D18).

3. Familial Searches

In cases where the police have found the perpetrator's DNA at the crime scene, but they do not have a profile on NDNAD, a search of the database, known as a 'familial search', can be carried out to look for possible close relatives (parents, children, or siblings) of the perpetrator. All such searches require the approval of the FIND Strategy Board chair or their nominee. A total of 22 familial searches were carried out in the UK 2023/24, so such searches are extremely rare.

Exchanges of DNA via the EU-UK Trade and Cooperation Agreement (TCA) and Prüm Framework

The UK formally departed from membership of the European Union at 2300 GMT on 31 January 2020 following the referendum held in the UK on 23 June 2016. Because of the EU-UK Trade and Cooperation Agreement (TCA) the exchange of biometric data specifically DNA and fingerprints between law enforcement continued under the former Prüm framework. This means that Police Scotland still can request DNA information held from convicted persons in EU member states in connection with the investigation of serious and organised crime. Likewise, Police Scotland can still receive exchange requests through the UK mechanisms administered on behalf of the UK by the UK National Crime Agency (NCA) and the Metropolitan Police.

In respect of DNA, there are exchange mechanisms in place with all 27 member states. This is crucial in the coordinated fight against terrorism, serious organised crime, and human trafficking where criminal networks operate extensively.

Figure 16. The reach of EU-UK DNA exchange for law enforcement purposes to the UK and all EU member states.

DNA relating to Missing Persons

Police Scotland may also submit DNA profiles pertaining to missing persons to the UK Missing Persons Database (MPD) which is distinct from the NDNAD. The purpose of the UK MPD is to hold DNA profiles of missing persons, unidentified bodies or body parts and profiles obtained from items from a crime scene where there is a link to a missing person's event. When a new DNA profile is added to the database, it is checked against the samples already held, to see if there are any matches. So, for example, when the DNA profile from an unidentified body is added, it is compared against the profiles held for missing persons. Profiles from the UK MPD are also exported to the Interpol DNA Database established in 2004 to help identify missing UK nationals who may be missing, abducted, or deceased overseas and this plays a crucial role in combatting issues such as human trafficking, the sexual exploitation of women and girls, and the fight against serious and organised crime and international terrorism. In 2021, Interpol also launched the Interpol i-Familia database which is a global database for the identification of missing persons and unidentified bodies and body parts through kinship matching.

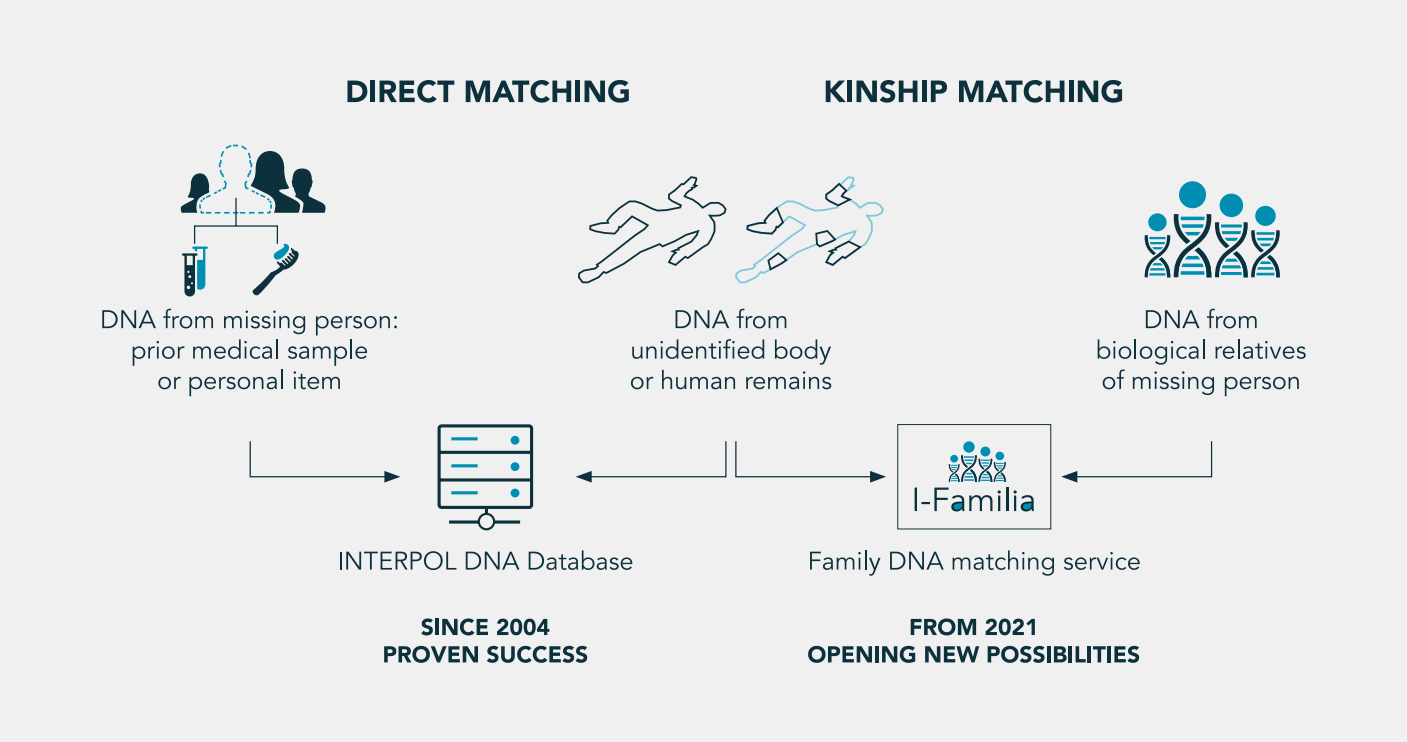


Figure 17. Interpol i-Familia DNA kinship searching schematic (Source: Interpol)

The use of kinship matching in the UK is rare with only 23 searches conducted in 2023 to 2024. Since 2021, one UK long-term missing person was matched through DNA on the i-Familia database to an unidentified body enquiry in an EU member state.

UK Vulnerable Persons DNA Database (VPDD)

The UK VPDD holds the DNA profile records of people who are at risk (or who consider themselves at risk) of harm (for instance due to child sexual exploitation or so-called honour-based assault) and have asked for their profile to be added. If the person subsequently goes missing, their profile can also be checked against NDNAD to see if they match to any biological material (such as blood or an unidentified body found at a crime scene) helping the police to investigate their disappearance. The taking of fingerprints and DNA samples is a key protective measure advised by National Police Chiefs Council (NPCC) guidance.

This is aimed at addressing identification issues in potential investigations and to protect potential victims from serious acts of violence, abduction, and homicide.[27]

As of 31st March 2024, there were 6,949[28] records on the VPDD. Twelve of these records were deemed searchable on the NDNAD, following approval from the DNA Strategy Board. None of these were from Scotland.

Subject and crime scene sampling error rates

As part of our Assurance Review, the Commissioner selected September 2024 as a sample month to look at the number of CJ DNA samples received by the DNA Administration Unit in Dundee. This showed that there were a total of 1783 samples received. 53 of those samples (2.97%) were then rejected by SPA Forensic Services. Of those accepted (1730), SPA Forensic Services found insufficient DNA to obtain a profile in 11 cases (0.62%). 50 of the 53 rejected samples were because the inner bag was incorrectly sealed by the staff taking the sample in the custody environment.

[27] ACPO Guidance on Taking of Fingerprints, DNA & Photographs of Victims / Potential Victims of Forced Marriage – Handling Procedures.
[28] This figure includes all datasets recorded on the VPDD.

We received assurances from Police Scotland that error rates are fed back to Criminal Justice Services Division to promote continuous learning and on looking at data for July, August and September the error rates were lower at around 2.2%. The error rates in Scotland are broadly like those reported by other UK Forces but are more challenging to remedy through training, given the size of Police Scotland where some 800 staff work in criminal justice at 62 sites.

Laboratory accreditation

Forensic Services providers carrying out DNA profiling work for loading to NDNAD must be approved by FINDS and the FIND Strategy Board and must hold accreditation to ISO/IEC 17025 as defined in the Forensic Science Regulator's Statutory Code of Practice.[29] As of 31st March 2024, fourteen UK laboratories were authorised to load profile records to NDNAD from standard processing. This includes SPA Forensic Services. SPA Forensic Services are not bound by the Forensic Science Regulators Statutory Code of Practice for England and Wales as its application does not extend to Scotland. Scotland does not have a Forensic Science Regulator, but SPA Forensic Services are bound by the Scottish Biometrics Commissioner's Statutory Code of Practice and more generally the provision of forensic services by SPA is subject to the independent oversight of HM Chief Inspector of Constabulary in Scotland (HMICS). SPA Forensic Services is independently accredited by and subject to an annual programme of scrutiny by the UK Accreditation Service (UKAS).

Emerging Technologies: Real-Time DNA

During our review, the Commissioner had the opportunity to discuss the development of Real-Time DNA technologies and their application to policing with the FBI Rapid DNA Lead and with the Head of Biometrics for the Metropolitan Police during a visit to London on 21 January 2025.

Real-Time DNA analysis is a term used to describe the fully automated process of developing a DNA profile from a reference sample mouth swab in 1-2 hours without the need for a DNA laboratory and without any human interpretation. The FBI is using Real-Time DNA to immediately enrol qualifying arrestees in the USA DNA Database CODIS so that every arrestee is searched against all unsolved crimes within 24 hours. The FBI also has established the DNA Index of Special Concern (DISC) containing complete crime scene profiles from unsolved homicide, sexual assault, kidnapping and terrorism cases. Using Real-Time DNA, DISC profiles can be searched in near real time during the booking process. A match to a DISC profile will result in an immediate notification to the booking agency, arresting agency and investigating agency. This technology has the potential to dramatically impact law enforcement's ability to generate investigative leads while an arrestee is still in custody, possibly preventing additional crimes and making communities safer. Rapid DNA is not currently approved for use on crime scene samples for enrolment and/or search in CODIS.

Real-Time DNA has been tested in the UK by the Metropolitan Police and evaluations are ongoing. Potential use case scenarios include for automation of criminal justice sampling, mobile solutions for disaster victim identification (DVI) in mass casualty situations and potentially in the future at crime scenes. It is too soon to know whether this technology may be of interest to Scotland, but currently it would not be suitable for forensic use in Scotland as the technology is not yet ISO accredited meaning that results could not be replicated in the laboratory.

[29] The Accreditation of Forensic Service Providers Regulations 2018 require (inter alia) competent law enforcement authorities to use Forensic Service Providers (FSPs) accredited to ISO/IEC 17025 or otherwise accredited in accordance with the EU/UK Trade and Cooperation Agreement, to conduct laboratory activities (including DNA profile activities or fingerprint data) for the prevention, detection or investigation of a crime.

Findings
iii. The impact of the use of DNA in Policing in Scotland

Overview
This third findings chapter engages with the 'impact' of the use of DNA in policing in Scotland by:

- Discussing the qualitative value of DNA.
- Explaining the value of DNA in Wildlife Crime investigations.
- Considering DNA in Fire Scene investigations.
- Exploring case studies involving murders and sexual offending.
- Exploring the value in specific Cold Case investigations.
- Celebrating a decade of success with the SPA FS Cold Case Review Team.
- Signposting to the future and final chapter of this review.

The Scottish DNA Database (SDNAD) Volumes

As discussed in the previous chapter, the extent of the use of DNA in policing and criminal justice as a means of confirming and verifying identity in Scotland is extensive. However, DNA is not a factor in most crime investigations in Scotland as most crimes are not exposed to the forensic recovery of DNA evidence. In 2023/24 there were 299,780 crimes recorded in Scotland of those 811 crime scene DNA recoveries were undetected and matched to an existing criminal justice DNA profile. There were also 213 instances of a person being arrested, having their DNA captured, and then matching to DNA from an unsolved crime scene.

We can therefore be confident that DNA has a low quantitative value when the number of matches is expressed as a percentage of all recorded crime. Although there was a total of 1,024 DNA matches in Scotland in 2023/24, this does not mean that DNA helped to solve that number of crimes as there are many innocent reasons for the presence of a person's DNA at a crime scene including the persistence of transferred materials. The official statistics also tell us nothing about the power of DNA in eliminating innocent people from police enquiries albeit this is thought to be significant.

DNA is easily transferred in innocent circumstances and (inadvertently), which is a consideration when reporting the scientific evidence, and can be remarkably stable over time if stored in the right conditions. In terms of stability, DNA preserves best in cold, dry environments. In a broader scientific context, this has enabled forensic scientists to decode the Neanderthal genome from skeletal remains more than 400,000 years old.[30]

[30] Ancient DNA and Neanderthals, Smithsonian Museum of Natural History, 2024.

Forensic Scientists have also been able to successfully profile Mammoth DNA from the molars of preserved skeletal remains which have been carbon dated to more than 1.2 million years.[31] The twin issues of transfer and persistence were brought into sharp relief after the Rotherham abuse scandal where it was discovered that DNA from semen could be found on clothes several months after they had been laundered at high temperatures. Scientists also found DNA on other items that had never been exposed to body fluids indicating innocent transfer taking place in a washing machine.[32]

However, although it is true to say that the use of DNA for policing and criminal justice purposes in Scotland has a low quantitative value when expressed as a percentage of all recorded crime, it is equally true to say that it has a very high qualitative value with crucial DNA evidence being a crucial factor in criminal proceedings involving some of Scotland's most notorious serial killers such as Robert Black, the paedophile who raped and murdered at least four young girls between 1981 and 1986 including Jennifer Cardy (9), Susan Harper (10), Susan Maxwell (11), and Caroline Hogg from Edinburgh who was only five years old. Angus Sinclair, most notorious for the World's End Murders who raped and killed at least four women and children between 1961 and 1978, and Peter Tobin, the sex offender who raped and murdered at least three young women in Scotland and England between 1991 and 2006.

The qualitative value of DNA

The qualitative value of DNA is therefore self-evident, but nevertheless it is helpful to look at some specific case studies under different scenarios to illustrate its valuable contribution both in the investigation of crimes and in the prosecution of offenders. From our review, we became aware of many recent and ongoing investigations where DNA is a critical component, however in accordance with sub judice rules, the following case studies are drawn solely from concluded prosecutions.

Case Study No 1.
DNA and Wildlife Crime

Man convicted of illegally selling peregrine falcon chicks agrees to repay £27,000

On 24 October 2024, the Crown Office and Procurator Fiscal Service (COPFS) announced the conviction of a man for illegally selling peregrine falcon chicks for large sums of money and ordered him to back pay £27,000 under the Proceeds of Crime Act. Lewis Hall (24) was banned from possessing or having under his control any birds of prey for 5 years after being sentenced in February 2024 at Jedburgh Sheriff Court. Hall and his father Timothy had claimed that the chicks were captive bred and they were being sold to wealthy clients in the Middle East. However, DNA evidence established that the chicks had been taken from wild nests. Detective Constable Steven Irvine, who led the initial Police Scotland investigation, said: "If we had allowed this practice to continue it would likely have wiped out the peregrine population in the south of Scotland."

[31] Mammoth molars yield the oldest DNA ever sequenced, Science.org, 2021.
[32] DNA in the dock: how flawed techniques sent innocent people to prison, The Guardian, 2017.

Case Study No 2.
DNA and Wildlife Crime

In September 2020 near Cupar, a farmer disturbed possible hare coursing on his land, which he reported to the police, giving details of a vehicle involved. A few days later the farmer's Land Rover was vandalised, with its windscreen smashed and a dead hare found lying next to the vehicle. The carcass of the dead hare was recovered by a Police Scotland Wildlife Crime Officer, and meanwhile the suspects' vehicle was traced by police and examined by a SPA-FS Scene Examiner who took a variety of samples from the interior in a bid to recover DNA from anyone who may have been a vehicle occupant, as well as swabs of blood from the vehicle interior.

The carcass of the dead hare and the samples from the vehicle allegedly used by the offenders were submitted for examination. Based on experience of examining similar cases, examination for offender DNA on the hare carcass focused on sampling the legs where the animal may have been grasped. A DNA profile from an unknown male was successfully obtained from the sample from the hare legs and from inside the suspect vehicle, and the DNA profile of a second unknown male was obtained from elsewhere inside the suspect vehicle. These two DNA profiles were then searched against the Scottish DNA Database and hits were obtained against two brothers whose profiles were held on the Database. The samples of blood from the interior of the suspects' vehicle were identified as dog blood by species testing at SPA-FS Aberdeen Laboratory.

The approach SPA-FS use for sampling of human DNA from animal carcasses and traps in wildlife crime cases was developed in a novel research collaboration with SASA (Science and Advice for Scottish Agriculture) and the University of Strathclyde. The results of this research were subsequently published in 2018 in Forensic Science International: Genetics, co-authored by two SPA-FS Forensic Leads Chris Gannicliffe and Steven Ferguson.

Case Study No 3.
DNA and Fire Scene Investigation
Murder accused DNA found in burnt-out car linked to gangland shooting.

On 10 May 2018, David Scott (33) was convicted of the gangland execution of Euan "EJ" Johnson on 15 November 2016 who was shot twice in the head as he sat at traffic lights at Shields Road and Scotland Street in Glasgow. The court heard David Scott's DNA was matched to a Nike top found in a burnt-out blue Audi A5 which was previously seen near the scene of a shooting in Glasgow. The shooting was linked to organised crime and Scott was jailed for 22 years.

During our review, we also learned of SPA Forensic Services working in partnership with the Scottish Fire and Rescue Service, Police Scotland, the Leverhulme Research Centre for Forensic Science, and independent fire investigation body Hawkins. This includes multi-agency training (including DNA recovery from crime scenes) and research collaboration at the Scottish Fire and Rescue Service training site at Portlethen. This is highlighted as good practice by the Commissioner as evidence of innovative practice in one of the most complicated areas of Forensic work.

Case Study No 4.
DNA in murder and sexual offending case
Brother convicted of sexually assaulting and strangling sister

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On 25 July 2023, Connor Gibson (20) was convicted of attacking his sister Amber (16) in woodland in Hamilton in November 2021. Gibson had removed Amber's clothing and had sexually assaulted her with the intention of raping her. He had inflicted blunt-force trauma to her head and body and had strangled his sister Amber. Both Connor and an unrelated male (Stephen Corrigan) who had intimately touched Amber's body after finding her dead and who had not contacted the police after finding the body were subsequently convicted with DNA evidence of contact being crucial to both cases. Gibson was jailed for 22 years, and Corrigan was jailed for nine years.

Case Study No 5.
DNA and child murder
Released paedophile kills 8-year-old boy

In June 2004, previously convicted paedophile Stuart Leggate (28), sexually assaulted, strangled, and murdered 8-year-old Mark Cummings before discarding his body in a garbage chute. He had previously been released from jail after assaulting male children aged between 3 and 10 years of age and was on the Sex Offender Register. He was sentenced to 20-years in jail meaning that he is now eligible for parole. After murdering Mark, he then drove to cliffs south of Berwick on Tweed and dumped the trousers he had used to strangle Mark along with a bloodstained towel. DNA evidence connected him to the murder. The high rates of recidivism amongst offenders generally, and paedophiles in particular place an imperative on policing to ensure that up-to-date biometrics, including the most advanced DNA profile is held given the inevitability of re-offending.

Case Study No 6.
DNA and historic cases
The murder of Mary McLaughlin

Mary McLaughlin was 58 years old and lived alone when she was found dead in her home on 2 October 1984. She was last seen alive on 26 September 1984, socialising in the Partick area. Mary was strangled with the belt from her dressing gown. She was wearing a dress, which was back to front, and no underwear. Her bra was found in the rear garden of the block of flats where she lived. The circumstances of her death suggested a sexually motivated crime. Despite extensive enquiries at the time, no one was identified as a suspect in 1984, or in the following years. A number of forensic reviews of this case were carried out in 1999, 2003 and 2008. The DNA analysis carried out from this era did not deliver any significant results.

In 2014 SPA Forensic Services launched the Cold Case Review Team. The first phase of work was the re-analysis of all the available DNA extracts that had been retained in frozen storage from the previous reviews (approx. 50 DNA extracts). From this first phase a full male DNA profile was obtained from a cigarette end found in Mary's house. This was searched on the DNA database and found to match the DNA profile of Graham McGill, a registered sex offender with criminal convictions for a rape (1980) and an attempted rape (1999). DNA attributable to Graham McGill was also identified in a semen stain from the dress worn by Mary McLaughlin (complex mixed DNA profile). Graham McGill was aged 22 at the time of Mary's murder.

The ligature was examined. The knot was untied, and a DNA taping taken from the protected area inside the knot. DNA attributable to Graham McGill was obtained from this taping. This was crucial to the subsequent court case. The bra was examined, and traces of semen were identified. DNA attributable to Graham McGill was found on 3 samples taken from the bra. (This item had not been examined in previous reviews). The advent of STRmix was crucial to the case, allowing statistical evaluation of the low level, degraded and mixed DNA profiles obtained from the dress, ligature and bra. On the 9th of April 2021 Graham McGill was found guilty of the murder of Mary McLaughlin and was subsequently sentenced to 14 years in prison.

Since the SPA Forensic Services Cold Case Review Team have worked on more than 70 cold case reviews applying the most modern scientific technologies to cases investigated in an era that did not benefit from such

Figure 18. SPA Forensic Services Cold Case Review Team.

Such technologies are constantly evolving presenting both new investigative opportunities and a range of ethical considerations. One such area is the development of a Y-STR (male only) Y Chromosome DNA reference database by the Home Office and enhanced use of familial searching of Y-STR in cases such as sexual offending. Such approaches are designed as a strategic policing response to the national emergency of male violence and sexual offending against women and girls, including the difficulties of translating successful investigations into successful convictions.

Figure 19. The Home Office Y-Chromosome reference database.

As can be seen from the foregoing, over the past 29 years DNA in policing has literally advanced from nowhere to becoming the most effective of all biometric technologies used in policing. In 1994, there was no NDNAD and no SDNAD but in 2025, NDNAD celebrates its 30th anniversary as the oldest policing DNA database in the world. As stated at the outset, DNA together with fingerprints is scientifically the most accurate and reliable of all biometric technologies. Where it might go in future is far from certain, but the possibilities are almost endless. Advancements in sample collection and extraction techniques, sequencing technologies, and bioinformatics tools are expected to enhance the depth and accuracy of DNA analysis in the coming years raising new investigative possibilities for policing. This may mean that forensic investigations can identify specific body fluids more easily or reveal biogeographic ancestry and thus the potential hair or eye colour of the subject and may even offer age determination. Some of these possibilities and the associated risks will be discussed in the following and final chapter of this review which has been independently produced for the Commissioner by the Leverhulme Research Centre for Forensic Science at the University of Dundee.

Future directions: Leverhulme
The future for DNA analysis in forensic science

The use of DNA analysis was introduced into the forensic science domain in the mid 1980's as the research relating to DNA and its connection to human genetics was developing. As such, the introduction of this disruptive technology to the investigative and justice landscape was opportunistic rather than scientifically or strategically planned. The next 4 decades saw predominantly technology-based developments, bringing increasing sensitivity and portability of the technology, while at the same time, developing large national DNA databases. These databases predominantly contain DNA information across only a small selection of specific regions of DNA rather than the whole genomic sequence.

During this 40-year time frame, the advances in understanding and scientific interpretation of DNA outside of the forensic science domain has, of course, developed greatly. The Human Genome project[33] and publication of the complete genomic sequence provided the foundation for revolutionary developments in human biology, laying the cornerstone for advancements in medicine and health care specifically. Such scientific developments have led to economies of scale, and genomic sequencing is now readily available to the public through private medical diagnostic tests opening up the area of personalised medicine[34], as well as being exploited for other commercial applications such as product authentication[35] and genetic ancestry testing.[36]

Adoption of new technologies: Could we – Should we?

Forensic science has existed largely outside of these scientific developments until reasonably recently when forensic science and DNA advancements have begun to coincide, or in some cases, collide.

Examples include the application of Massively Parallel Sequencing (MPS) to improve the analytical success in working with mitochondrial DNA, degraded DNA and DNA mixtures as well as applications to environmental samples such as the identification of plants and pollen.[37] Genetic phenotyping[38] is also developing opportunities for providing information such as eye colour, hair colour and face shape. Some of these technologies are already being applied in forensic science particularly in the identification of unknown individuals.

Research and development is exploring the forensic science opportunities of environmental DNA (eDNA), the genetic material left by organisms in the environment, and how this could provide investigative links between people and places[39] or in the investigation of wildlife crime.

Microbiome detection of, for example, bacteria, fungi and viruses have also been recently elevated in terms of both research funding and research output as well as operational application, during and post, COVID. The developing area of microbial forensics sees the application of these 'omic'[40] technologies being explored for forensic science applications.

[33] https://www.genome.gov/human-genome-project
[34] https://www.nature.com/subjects/personalized-medicine
[35] https://euipo.europa.eu/anti-counterfeiting-and-anti-piracy-technology-guide/
[36] https://www.nist.gov/how-do-you-measure-it/health-and-nutrition/how-do-companies-measure-dna-discover-your-ancestry
[37] https://wires.onlinelibrary.wiley.com/doi/10.1002/wfs2.1531
[38] https://www.sciencedirect.com/science/article/pii/S1872497323000455
[39] https://analyticalsciencejournals.onlinelibrary.wiley.com/doi/full/10.1002/elps.202300228
[40] Genomics, proteomics, metablaomics.

The potentially enormous data sets associated with these types of analysis require a bioinformatics approach to interpretation which, up to now, has not been presented within the Courts in any mainstream way. Similarly, any cross over of microbial forensic analysis into potential evidential provision will most likely need new process and practice relating to scene investigation, sample collection and contamination avoidance that are largely as yet unexplored.

Perhaps the best example of collision is demonstrated in the emergent use of (forensic) investigative genetic genealogy[41] where its introduction, initially in the USA, carries with it significant ethical and data privacy issues which may not be easily resolved. This, together with potential weaknesses around accreditation of the genealogy component of the process to a standard satisfactory to the Courts, may pose considerable questions around mainstream operational implementation.

Adoption of scientific advancements and associated new technologies create risk for implementation into the Justice space, not least because the ultimate customer is the Court system and the public. This requires that adoption must demonstrate not only scientific resilience and validity in terms of accuracy, repeatability and reproducibility both in testing and operational application, but also that these technologies are acceptable to the Courts and comply with their established admissibility requirements.

Challenges in interpretation, evaluation and communication

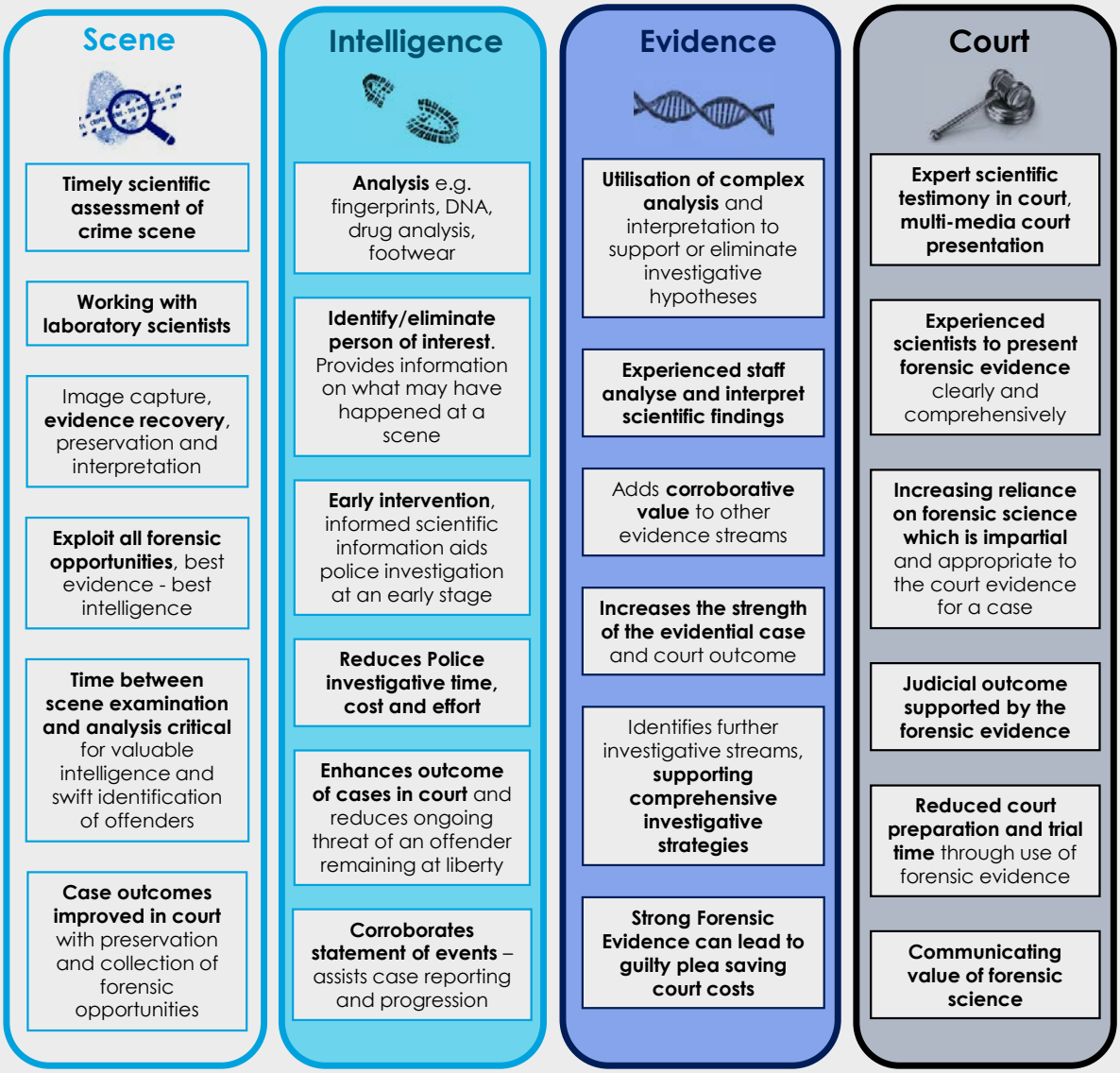
One of the most significant areas for future development is not technological but evaluative. Scientific evidence is most useful when it is evaluated in light of the framework of circumstances of the narrative of a case. This is particularly true for DNA evidence and as the critical questions move away from who's DNA has been recovered, to how did that DNA get to where it was recovered from? This requires investment, both financial and in research, to understand the transfer of DNA from surface to surface, between people and between people and surfaces given alleged activities. Understanding of the persistence of DNA once transferred is also critical in the evaluation of its meaning when recovered (assuming that it can be recovered) and these understandings, together with information about background prevalence of DNA enable the traces recovered, analysed and reported to be meaningfully evaluated within a case context.[42] [43]
The future will also bring great opportunities for implementation of Machine Learning and Artificial Intelligence applications to the large data sets often associated with the interpretation of DNA samples, but of course these will require investment in the appropriate data sets for training and validation.

The communication of these sometimes, complex, issues is also the responsibility of the forensic scientist and an area where technical assistance in data visualisation and science communication skills will become more common place in the Courtrooms of the future. The importance of incorporating forensic science thinking from the crime scene, where potential evidence is gathered, to the Court room where the relevance and value of the scientific findings relating to recovered evidence is evaluated in context and communicated in an understandable way to the Judge and Jury, is a critical aspect of the future direction of DNA evidence specifically, and forensic science more broadly.[44] This is an area where Scottish forensic science practitioners perform particularly well.

The advancement in the scientific understanding of DNA and the technology which is developed as a consequence has the potential to provide enormous opportunities for forensic science but must be implemented carefully and appropriately being mindful of the evaluative and Justice system needs.

[41] https://assets.publishing.service.gov.uk/media/5f58e834d3bf7f7237cf3e59/BFEG_Genetic_Genealogy_Final.pdf
[42] https://www.fsigenetics.com/article/S1872-4973(24)00005-X/fulltext
[43] https://www.fsigenetics.com/article/S1872-4973(24)00147-9/fulltext
[44] https://www.sciencedirect.com/science/article/pii/S0379073822000123

Appendix
a. The Crime Scene to Court model for Scotland



The **Crime Scene to Court** model maximises the value which can be driven from the application of forensic science as it improves speed and coordination across the entire forensic process.

Forensic science continues to develop so being able to join all forensic processes together and co-ordinate functions within one organisation gives Forensic Services a leading edge in Scotland providing the best possible service to the public we serve.

Continued investment in forensic science will provide considerable downstream benefits across the justice system. Working with justice supporting organisations to identify better ways forensic evidence can be realised will further strengthen outcomes and the level of value delivered.

Our communities are safer places from the timely application of forensic science and services.

Appendix
b. Glossary

AI	Artificial Intelligence
BFEG	Home Office Biometrics and Forensics Ethics Group
CE	Capillary Electrophoresis
CHS	Police Scotland Criminal History System
CID	Criminal Investigation Department
CJ	Criminal Justice
COPFS	Crown Office and Procurator Fiscal Service
COS	Core Operating System
DNA	Deoxyribonucleic acid
DNA24	DNA analysis of 24 genetic markers
DNAC	DNA Confirmed
DPA	UK Data Protection Act 2018
EU	European Union
EqHRIA	Equality and Human Rights Impact Assessment
FPN	Fixed Penalty Notice
HBV	Honour Based Violence
ICO	UK Information Commissioner
ICT	Information Communications Technology
ISO	International Standards Organisation
LRCFS	Leverhulme Research Centre for Forensic Science
mtDNA	Mitochondrial DNA
NCA	UK National Crime Agency
NDNAD	UK National DNA Database
MPD	UK Missing Person Database
NOA	Not Officially Accused
NPCC	National Police Chiefs Council
PCR	Polymerase Chain Reaction
pH	Potential of Hydrogen (acidity level)
PIRC	Police Investigations and Review Commissioner
rDNA	Recombinant DNA
RNA	Ribonucleic Acid
SCRS	Scottish Crime Recording Standards
SBC	Scottish Biometrics Commissioner
SDNAD	Scottish DNA Database
SOP	Standard Operating Procedure
SPA	Scottish Police Authority
SPA FS	Scottish Police Authority Forensic Services
STR	Short Tandem Repeat
STRmix	Short Tandem Repeat (complex mixture)
UKAS	UK Accreditation Service
UV	Ultraviolet
VPDD	UK Vulnerable Persons DNA Database
Y-STR	Short Tandem Repeat (STR) on the Y-chromosome

Leverhulme Research Centre
for Forensic Science
University of Dundee

SCOTTISH POLICE
AUTHORITY
ÙGHDARRAS POILIS NA H-ALBA

Scottish Biometrics Commissioner
Coimiseanair Biometrics na h-Alba

Safeguarding our biometric future