Efficiency of dna databases as criminal investigative tools

Science, Genetics

DNA Fingerprinting

Alec Jefferys discovered variable number tandem repeats (VNTR) in 1984. In 1985 he applied the restriction fragment length polymorphism (RFLP) technique to create a “ DNA fingerprint” (Jeffreys et al., 1985). RFLP is a technique where the DNA was cut to where a specific sequence of bases occurred using restriction enzymes (Panneerchelvam et al., 2003). This gave small pieces of DNA that varied in length. This was a big innovation in forensic science as it allowed to create profiles that were specific to an individual (van Camp et al., 2007). The use of this technology and this technique required a large amount of DNA to be present to create a fingerprint. This caused a serious issue for the forensic samples, one of the other major drawback was that it was a time-consuming process which is not easily available during a criminal investigation and it also required intensive labour work (Decorate et al., 1993).

Kerry Mullis invented the Polymerase Chain Reaction (PCR) in 1986 which improved the efficiency of DNA testing (Mullis et al., 1986). The VNTR analysis improved with the introduction of PCR as it enabled the analysis of small amounts of DNA. The use of VNTR with PCR cause problems such as the shorter alleles were amplified but the longer alleles were undetected and were not amplified (Decorate et al., 1993). This led to the discovery of Short Tandem Repeats (STRs). These were much smaller than VNTRs and hence were all detected and amplified efficiently. The transition from VNTRs to STRs for DNA analysis made it possible to successfully analyse degraded DNA and trace DNA significantly quicker (Decorate et al., 1993).

The increased sensitivity of PCR made it susceptible to contamination and therefore strict protocols were followed while using PCR (Panneerchelvam et al., 2003). Due to fewer alleles in STRs ore loci were required to produce information about the likelihood of two people sharing a profile (Smith et al., 1997) and hence STR multiplex system was introduced. This system allowed many STR loci to be simultaneously analysed (Gill, 2001). The use of fluorescent labels, automated sequencing technology, and commercial STR kits, the PCR-STR technology became the preferred technology for the use in forensic laboratories. (Kashyap et al., 2004).

Trace DNA

Trace DNA sample is a sample that falls below the recommended threshold at any stage during its analysis, this is from the sample collection, through to profile interpretation as defined by Van Oorschot et al. (2010). Terms such as touch DNA, low template DNA (LT-DNA), low copy number DNA (LCN-DNA) and low-level profile are used interchangeably. (Van Oorschot et al., 2010). All the terms given above although used interchangeably have different relevance at different stages during DNA analysis (Van Oorschot et al., 2010). The terms Touch DNA refers to the minute amount of DNA collected and/or extracted whereas low template defines the minute mount od DNA material used during the amplification stage; low copy number relates to the increased cycle number during amplification rather than the amount of DNA material, a profile is referred to as low level when the peak of heights is below-validated threshold level.

To enhance the sensitivity of the standard PCR method an easy technique is used. This is where the number of cycles is increased from 28 to 34. (Gill., 2001; Kloosterman et al., 2003). This increased sensitivity of the LCN technique of increasing the cycles has enabled the recovery of DNA from touched surfaces. The implication of the use of this technique has increased the evidentiary value of items collected from crime scenes (Gill., 2001). Previously, DNA testing was mainly used to help solve crimes such as homicide and rape but with the ability to detect ‘ touch DNA’ from evidence collected from crime scenes such as robberies, break-ins, and hijackings has allowed for recovery and typing of DNA which in turn has allowed more DNA recovery from more types of evidence such as from masks worn on the face during robbery to bite marks left on victims of rape or homicide.

The LCN-DNA technique although provides increased sensitivity has its own drawbacks. The increased number of cycles during PCR gives larger stutter peaks, allele drop-ins and/or out, heterozygote imbalance, locus drop-outs and the occurrence of unknown allele peaks or contamination. (Gill et al., 2000; Kloosterman et al., 2003; Forster et al., 2008). Contamination can occur at any point during and within the chain of custody, it is the transfer of DNA after the crime event (Gill, 2001). A small amount of DNA contamination isn’t a major problem when dealing with a high amount of DNA input but plays a major role and has a major impact when dealing with low template DNA analysis. LCN DNA analysis is in practice by the majority of the forensic laboratories, the strength of evidence derived from this type of DNA analysis has decreased compared to the conventional DNA analysis methods. This is

due to the uncertainties that relate to the method of transfer of the DNA and how and when the DNA was transferred (Gill, 2001) along with the interpretation and reporting of the results obtained (Linacre, 2009). Foster et al. (2008) investigated methods other methods that can be used to enhance the 28 cycle PCR so that the problems that were the result of an increased number of PCR cycles can be reduced. From their study, they concluded that by combining PCR product clean-up, concentration, increased sample loading along with increased injection parameters the same or even better quality STR profiles were produced from 28 cycle PCR as those that were generated using the LCN method of 34 cycle PCR.

DNA testing and the law

Forensic application of DNA analysis is wide and cover a large spectrum of cases from criminal cases to missing persons' case including wildlife cases making DNA testing and analysis an undisputed asset in the law enforcement. The first legal application of DNA profiling in the United Kingdom dates back to 1985 by Alec Jeffery's for an immigration case. (Saad, 2005). DNA profiling has been used to solve serious crimes for a long time but in recent years is being used to solve volume crimes. The first case to use DNA profiling solved by Alec Jefferys was also the first case where the DNA analysis and profiling technology helped exonerated an innocent person. In 1985 Alec Jeffery was called to assist the police with a double rape and murder case in Leicestershire. The case was that a person who had confessed to one of the crimes, three years apart. DNA profiling liked both the crimes but excluded the suspect from both these scenes (Fourney, 2002). This success prompted the use of DNA profiling in criminal

investigations including cold cases missing persons' cases, mass disaster cases, parentage cases and exonerations of those who were wrongfully convicted (Campbell 2011). There are many reasons for wrongful convictions as suggested by research, DNA is one of the most important tools that is utilized to prevent and uncover wrongful convictions. It has also been determined that with access to DNA testing within the criminal justice system the likelihood of exoneration for murder and sexual assaults increase by 6. 93 times. (Olney et al., 2014).

As the technology advances new problems emerge although while acknowledging the benefits of DNA testing. From the beginning, it was presumed that if DNA was found at or near the crime scene that individual was present at or near the crime scene. Due to the existence and understanding of secondary or multiple DNA transfers, it can no longer be taken that one's DNA at any place means an interaction with the environment or presence at the scene. Further studies and experiment showed that secondary DNA transfer is possible, and this cannot be ignored. To determine the validity of the theory of multiple DNA transfers many studies and experiments were conducted. Different conclusions were drawn regarding the phenomenon of criminal investigations based on the method of analysis. Some concluded that secondary DNA has an impact on the routine analysis of DNA (Farmen et al., 2008; Aditya et al., 2011) whereas some concluded to the contrary (Ladd et al., 1999; Daly et al., 2012). This theory of secondary transfer has created issues in court as lawyers are increasingly proposing scenarios where multiple transfers may have

occurred as an explanation for the presence of a person’s DNA at or around the crime scene (Goray et al., 2010). This has thrown a curve-ball to the application of DNA in criminal investigations.

DNA database

The need for comparison of profiles between cases and across jurisdictions drove the forensic community towards the use of consensus STR loci for the generation of DNA profiles. This need for comparison also motivated for the development and the establishment of the national DNA databased in various countries. the collection of DNA profile in this database has been a big asset than just DNA analysis alone.

The DNA database works like a scientific tool for the law enforcement to supplement conventional investigating techniques. In cases where a suspect already exists a DNA profile on its own could be useful as it makes comparing the sample from the crime scene and the profile of the suspect simple. If a suspect is not present and the conventional investigation have failed to present a suspect the sample collected from the crime scene becomes useless as there is nothing or no one to compare it with. In cases like these, the DNA database comes in handy and the role of the DNA database becomes significant. The database is used as an investigation tool to identify serial offenders, link crimes and sometimes identify suspects. Every time a new profile is uploaded on the database, it automatically compares itself with the present profiles already on the database to find a hit. This can be used for intelligence purposes (Interpol, 2009).

Ideally, a DNA database contains profiles for convicted offenders and crime scene samples although it is not limited to that. The database can also contain profiles from suspects, those who are arrested, missing persons and volunteers. The profiles of the volunteers whether to be kept or not depends on the legislated structure (Interpol, 2009). The UK database was established in 1995 using a six STR loci multiplex, New Zealand followed and the United States of America (US) established theirs in 1998 (Campbell, 2011). Many more countries have since then made their own national DNA databases according to Interpol as of 2009, 120 countries use DNA profiling as part of their criminal investigations and as a criminal investigation tool (Interpol, 2009). The UK has the largest National DNA database per capita while China and the United States maintain the two largest DNA databases in the world in terms of the size. In March 2014, the United Kingdom’s national DNA database contained 5, 716, 085 reference profiles and around five hundred thousand of the profiles were from scene of crimes and represents approximately 9% of the country’s population whereas China’s national DNA database contains over 20 million profiles and the United States’ national DNA database contains around 12 million profiles.

The benefits of DNA database are many. With the use of the national DNA database (NDNAD), law enforcement agencies have been able to solve cases which would’ve ended as a mystery otherwise. DNA databases enable the ability to provide clues that could effectively lead to the identification of a suspect. This has made the database invaluable in the fight against crime. The hits between existing profiles and newly uploaded profiles provide a

crucial lead while conducting a criminal investigation, this, in turn, saves a lot of time and resources that would otherwise be spent on the investigation. The DNA database is only used for criminal investigations, it is also a good tool for missing persons' and mass disasters. Using the DNA database as a tool, China has managed to identify and rescue 2455 trafficked children's as of June 2013 and the US has solved 3499 missing persons cases as of August 2012 (Ge et al., 2014).

DNA databases can also serve as a deterrent for future crimes. Having an individual's DNA profile on file will increase the risk of the individual getting caught if he/she commits a crime, this fear prevents crimes. This argument has been put forward by the government while suggesting the expansion of the database. Doleac (2012) noted that the effect of DNA profiling on recidivism varied depending on the offenders age and their past criminal activities. Or criminal history. No effect was observed on older offenders that only had one previous convictions but young offenders with multiple convictions showed to have the largest effect. In another study Bhati et al. (2014) observed the deterrent effects of DNA database and concluded that there was no real evidence of deterrence, in particular for property crimes such as burglary or robbery.

Another major benefit of a DNA database is that there is a potential to thwart cross-border criminality. The national DNA database for all countries were built from the same core set of markers as set out and validated by the National Institute of Science and Technology (NIST). This allows the transfer and exchange of information between different countries and/or jurisdictions

possible. To make this exchange work more efficiently Interpol has set up its own DNA database called the DNA Gateway, this is where the member countries can run profiles looking for hits from profiles uploaded by other countries or states (Interpol, 2009). As a result of this by 2013 this database contained 140, 000 DNA profiles that were contributed by 69-member states. The searched performed through these profiles has resulted in 86 international hits (Interpol, 2009).

The use of DNA databases, as good a tool as it is for criminal investigations, has raised concerns which are rather justified. Campbell (2011) argued in the context of an un-convicted person that the collection and storage of the DNA profile on the DNA database encroaches the right to bodily integrity, affects the rights to privacy and also effects the presumption of their innocence and can give a biased opinion. Also adding profiles of those arrested for petty crimes increases the number of profiles on the database. This increase in the profile could lead to a higher rate of hits, this could also increase the probability of having adventitious hits that could lead to a miscarriage of justice. DNA evidence relies upon statistical probability.

The efficiency of a database stems from the law that establishes it. The legislation provides for the most appropriate use of the database (Asplen, 2004) and differs from country to country. The DNA legislation prescribes for the administration and custody of the database, inclusion criteria for profiles and storage of both DNA samples and profiles. In some countries only convicted offender’s profiles are entered into the database but not those of suspects (e. g. New Zealand, France); in some only convicted offenders with

some prescribed sentence are entered (e. g. Netherlands, Sweden) and in some, a profile is entered into the database for suspects for any recordable offense (e. g. UK, Austria, Switzerland) (Jobling et al., 2004). Retention criteria also differ from country to country according to the severity of a crime (Netherlands) or outcome of a case (Finland) or some prescribed term by law. The size of each database 12 thus depends on the criteria set out in the law for inclusion and retention of profiles. As a matter of fact, the reason behind the NDNAD's size is that a series of laws were introduced in the UK which systematically led to the expansion of the database.

The Police and Criminal Evidence Act 1984 (PACE) allowed for the sampling of DNA from individuals charged with serious offenses. Then in 1994, the Criminal Justice and Police Act (CJPOA) established the NDNAD and routinised DNA collection by allowing collection of a non-intimate DNA sample without consent for any recordable offense. An amendment to the CJPOA in 2001 further allowed the police to permanently retain both the DNA sample and profile of all those sampled even if not convicted or cautioned for any crime (Johnson et al., 2003). These changes resulted in many people's profiles being included in the NDNAD, most of them innocent. This, however, has since been amended to limit the scope of inclusion as well as retention. Following the case of R vs S and Marper in the European Court for Human Rights where it was ruled that retention of a DNA profile after acquittal contravenes one's right to privacy, the UK amended its legislation to introduce retention periods according to the type of crime suspected (Wallace et al., 2014). The enactment of the Protection of Freedoms Act

2012 (PoFA) also resulted in the deletion of over a million DNA profiles belonging to people not convicted of any crime from the database in the year 2013/14 (UK, Home Office).

Technically, the more profiles a database contains, the higher the hit rate will be. With every new profile that is entered, the probability of obtaining a match increases, it is thus reasonable to assume that hit rates are correlated with improved effectiveness of the criminal justice system. Goulka et al. (2010) note the dangers of using either the database size or the match rate as measures for effectiveness of a DNA database. They argue that hit rates are output measures not outcome measures and a higher hit rate does not necessarily mean more offenders have been apprehended and prosecuted. This point is clearly illustrated when one looks at the UK database statistics. The NDNAD statistics from 1998 to 2012 clearly show that match rate is not the correct measure for efficiency of a DNA database (Wallace et al., 2014). With the increasing number of profiles kept in the NDNAD, one would have expected that more crimes would have been solved. This however has not been the case; in fact the increase in the size of the database seemed not to make any difference to what is termed DNA detections, meaning crimes where a match led to prosecution in a court of law. Fig. 1. 1 shows that whilst there has been a steady increase in the size of the NDNAD from 2003 to 2012, the detection rate has remained more or less constant at 0. 36% (Wallace et al., 2014).