

Concepts of dna fingerprint and forensic analysis essay sample

[Science](#), [Genetics](#)



What is DNA Fingerprint?

Be it in movies, television or books and magazines, DNA has constantly been hailed as the 'building blocks of life'. DNA is present in every living organism. It is a molecule that encodes the basic genetic instructions for the development and functioning of an organism. This set of genetic instructions determines our physical characteristics such as eye colour, hair colour, the proneness to having acne, or even life threatening diseases. Although the basic chemical structure of DNA is the same for all human beings, there are stark differences present in the order of the base pairs in the chromosomes. In every strand of DNA, there is an inert portion of DNA which contains repeated sequences of 1 to 100 repeated base pairs of chromosomes known by scientists as Variable Number Tandem Repeats (VNTR).

The VNTRs are unique to each individual and it is the variability in the assembly of Nucleotides (biological molecules that forms DNA) in the 23 pairs of chromosomes which give each and every one of us a unique identity. This variability in the DNA of every individual is a unique feature which gives rise to the concept of DNA fingerprint. Another unique aspect of DNA lies in the fact that it is uniform in every cell of an individual organism. Although each cell in a human body has different functionalities; Hepatocyte cells (liver), Nonstriated duct cell (sweat glands), Cardiac muscle cells (Heart), etc, all these cells contain a similar copy of DNA that defines our organic structure as a whole. This is the reason why the DNA found in a strand of hair will be a perfect match with the DNA found in a drop of blood. These two unique features of DNA are the main reasons why DNA fingerprint is

possible, and is the driving factors that make DNA fingerprint an indispensable tool in modern forensics science.

Forensic Science

Forensic science is the application of science in criminal justice. It involves the gathering of samples and evidences in a crime scene which will subsequently be used to prove the innocence or guilt of an accused in connections with a crime. Over the years, the development of new technologies has aided criminal investigators with their crime investigations. The advent of the camera in the late 19th century proved to be a breakthrough in the identification of suspects in that era. Photographs replaced hand drawn "Wanted" posters which were mediocre at times. However, the use of physical disguises could easily foil a conviction based on photographic images. Hence photographs were ineffective at times. Other methods such as the use of Polygraph Machines were also not judicially acceptable as their results were often questioned in court of law.

The next breakthrough in forensic science was the discovery of fingerprints. The arches on the skin of human finger tips varied from one individual to another. Thus, the uniqueness of each individual's fingerprints meant that fingerprints found at a crime scene can help in confirming whether a suspect was indeed the culprit. Despite its accuracy in identifying and convicting suspects, fingerprints can be easily removed from a crime scene by wearing gloves or with a clean wipe. Hence, criminal investigation cannot rely solely on fingerprints as criminals got smarter. On the other hand, DNA fingerprinting has been proven to be a more effective method in the

identification of criminals as compared to photos and fingerprints. Relying on the two aforementioned unique features of DNA, DNA fingerprint is a more reliable method as hair or bodily fluids left behind at crime scenes can be used to trace a suspect to the crime. The results from the DNA fingerprint are highly conclusive and there is an extremely low probability that two individuals will have the same results, unless they are twins. Furthermore, just a minute amount of cells left over at the crime scene will suffice in convicting a suspect; I will elaborate on this with greater detail in the next section.

DNA Fingerprint Methods

Restriction Fragment Length Polymorphism (RFLP)

The RFLP is a method of isolating VNTRs. It is an early method used in DNA profiling. From my understanding, DNA located at a crime scene is treated with an enzyme known as Restriction Endonuclease which is found in E. coli bacteria. The enzyme targets and cuts DNA wherever there is a sequence in the DNA strand. The fragmented strands of DNA are then separated using a process called electrophoresis, which sorts the fragments base on sizes while in a gel like substance. The next step is called the 'Southern Blot Technique'. Fragments are then transferred to a nylon membrane which is incubated with a radioactive short strand of complementary DNA called the 'Probe'. The fragments will bind together with the probe in a process called hybridization. The probe makes the fragments radioactive, thus images known as 'Autoradiographs' can be seen when an X-ray film is placed on the nylon membrane.

The autoradiographs present bands at different positions on the film which are used to compare the autoradiograph with another autoradiograph; presumably results from DNA of the apprehended suspect. A match in the bands will render the suspect guilty of the crime. However, there are some drawbacks to the RFLP method. If the DNA evidence is old or only present in small amounts (RFLP requires several thousand cells), RFLP testing method will be unsuitable. This limits the RFLP's effectiveness where crime scenes have limited DNA evidence to be recovered. There are also other drawbacks to the RFLP method which I have researched: In the past, handling of the radioactive probes is a health risk to scientists conducting the RFLP method due to the radiation. Furthermore, the gels used to separate the fragments can also render the RFLP process time consuming as analysis is required in estimating the amount of DNA fragments that can be recovered during the electrophoresis process. Therefore, as a result of these impediments, the RFLP method has since been replaced by more efficient and effective methods.

Polymerised Chain Reaction (PCR)

The PCR is another method used in DNA fingerprint. The PCR's main advantage over the RFLP method is its unique ability to amplify minute amount cells into an amount which can be utilized for analysis by criminal investigators. The entire process of the PCR is likened to a photocopying machine that replicates cells. Primers, which are short custom built pieces of DNA, are used to seek portions from the DNA evidence to be used for comparison. Similar to the radioactive probes in RFLP, the primers seek

complementary portions of the suspect's DNA. Once the complementary portions have been identified, an enzyme Taq polymerase and DNA nucleotides aid the replication process while the portions are put through repeated cycles of heating and cooling. Heating the portions up to 94°C - 96°C causes a disruption in the hydrogen bonds, thus yielding single-stranded DNA molecules.

The next step is known as the 'Annealing' step, whereby the temperature is lowered to between 50°C - 65 °C where the polymerase starts binding to the primers and begins DNA formation. The temperature is subsequently raised to 50°C - 65 °C. This is where the DNA polymerase produces a new DNA strand. Since the DNA strand produced during the PCR is identical to the original DNA from the sample evidence, there is no need for electrophoresis. This saves time in the aforementioned analysis required in the RFLP method. The replicated DNA is applied on special blot strips where each dot on the strip contains a different DNA probe.

The DNA probes are attached to an enzyme which changes the colour of the dots when binding occurs. As the probes are not radioactive, they present another advantage over the RFLP method which uses radioactive probes that may pose health risks to the scientists. However, one disadvantage of the PCR method is its high sensitivity to contaminated evidence. Whether the evidence is contaminated at the scene or at the lab, the contamination will result in the duplication of millions of wrong DNA. This is one of the disadvantages in DNA fingerprint which I will elaborate later in this paper.

Short Tandem Repeats (STR)

The latest method in DNA fingerprint is the STR method, which is based off the PCR method. It involves the extraction of nuclear DNA from a sample. Analysis is performed on specific STR regions within the nuclear DNA. These specific regions are targeted using sequence-specific primers. The DNA fragments are then amplified using the PCR method. The fragments will then be separated using electrophoresis which finds out the number of repeats of the STR sequence. The variability in STRs is used to discriminate one DNA profile from another. Different dyes are used to provide a visual comparison of the DNA. The STR method is currently adopted in DNA profiling today. In North America, the Federal Bureau of Investigation (FBI) funds a DNA database known as the ' Combined DNA Index System' (CODIS) which stores has DNA fingerprints of arrestees. CODIS utilize a standard practice of 13 STR regions to distinguish the results. Similarly, the UK National DNA Database (NDNA) was established to record the DNA of felons in the United Kingdom.

DNA Fingerprint: Benefits in Forensic Analysis

The ability to amplify DNA samples and the conclusiveness in the results are the main benefits of DNA fingerprint in the realm of forensic science. Unlike fingerprints which can be removed easily, I believe it is not easy to expunge all traces of bodily fluids from a crime scene. A felon may try to destroy all evidence by cleaning up the crime scene; however, no matter how thorough, all that is required is a left over mist of blood to convict a suspect. This can

be attributed to the PCR method which can be used to amplify the DNA in the sample. This was the case for Singaporean, Leong Siew Chor, who was charged in 2006 for murdering a Chinese national. Leong had tried his best to clean up his apartment's toilet of any traces of blood after dismembering the young lady in it. Nonetheless, a spot of blood was found behind the toilet bowl. That was enough to trace the DNA in the blood to the victim and charge Leong with the murder.

The conclusiveness of DNA fingerprint has also benefited those who were accused of crimes which they did not commit. DNA fingerprint has exonerated the innocent who were given capital punishment. However, I personally feel that DNA fingerprint is especially helpful to those who have been wrongly accused, and do not have the capacity to make proper judgements due to mental incapacities. Earl Washington was a mildly retarded US farm worker who admitted to being the assailant involved in a rape-cum-murder case when the case was brought up by the police during interrogations in 1983. He was innocent, but was incarcerated based on his confessions and his inability to represent himself due to intellectual incapability. He was only pardoned in 2001 after two separate DNA tests on the victim's vaginal swab concluded that it did not match Washington's DNA. If not for DNA fingerprint, Washington would have spent his life in prison for a crime he did not commit.

DNA fingerprint also opened doors to crimes which were previously unsolved. Before PCR was available, family members of murdered victims would have been left in despair knowing that there was no hope in finding who was/were

responsible for the crime. However with the PCR method, as long as evidence collected at a crime scene contained DNA, cold cases can be re-opened for investigation. An example is the case of Mia Zapata who was raped and murdered in Seattle, US in 1993. Her assailant was able to roam free for 10 years before the DNA taken from Zapata's body was entered into CODIS in 2003. A match was found and her assailant, who had a history of assaulting women and domestic violence, was immediately apprehended and sentenced accordingly. I believe DNA fingerprint definitely provides some form of closure to the families of victims involved in such cold cases. Thus, DNA fingerprint is a means of ensuring that justice is brought upon those who have commit serious crimes regardless of whether they occurred in the past or present.

DNA Fingerprint: Controversies in Forensic Analysis

Contamination and Human Error

Regardless of the benefits stated in the previous section, DNA Fingerprint has its own downside. Although the results from DNA fingerprint are highly conclusive, human error is usually the cause in the contamination evidences at the crime scene or at the lab which ultimately leads to void results. The high-profile case involving the murder of Nicole Simpson and Ronald Goldman highlighted the importance of proper techniques in evidence collection by criminal investigators. LAPD criminal investigator Dennis Fung had committed a number of grave mistakes in his collection of the evidence at the crime scene; he used the same tweezers when touching

different samples, he tainted the crime scene by touching the floor, samples were placed in a plastic bag which induced condensation, etc. These were some of the mistakes which the defence lawyers attacked stating that the 'rules of evidence' were not adhered and resulted in tainted evidence.

Hence, the evidence cannot be used in the prosecution of O. J. Simpson, who was initially charged with the double murders. Even if the contamination is avoided in the collection of evidence, it can still happen in the laboratories where the analysis takes place. Human error can occur in the form of mislabelling, careless handling of evidence, or improper storage. Research has shown that morgue instruments often have DNA of at least three different individuals on them. Such occurrences will certainly cause DNA Fingerprint to have in-accurate results. In addition, there have been cases of switched DNA samples in labs. One such error in Nevada eventually led to an innocent man spending four years in prison.

In my view, I find that DNA fingerprint is an effective method in identifying perpetrators, and the technique itself works brilliantly. However, as humans are not infallible, we are usually the culprits who cause effective procedures to be ineffective. Therefore, even if the strict rules and measures are enforced during collection and analysing of evidence, lapses will still happen once in a while. Once such lapses occur, it will render evidences unreliable and crimes may remain unresolved; just like the Simpson and Goldman case.

Planting of DNA by criminals

Like how criminals have outsmart criminal investigators by wearing gloves to avoid detection of their fingerprints, criminals may also adopt various methods to confuse criminal investigators by planting unknown DNA to foil investigations. In 1992, Canadian physician John Schneeberger planted fake DNA evidence in his own body to avoid suspicion in a rape case. He was able to avoid being charged for a number of years. Personally, I find it easy for criminals to leave traces of hair or a cigarette bud from an unknown source at the crime scene to fool investigators. Investigators may not be able to trace the perpetrator in such cases.

DNA Profile Database

There are also controversies in the storage of DNA data of suspects and criminals. The main difference between fingerprint databases and DNA fingerprint databases is that fingerprints are useful only as an identification purpose. On the other hand, DNA not only provides a form of identification, but with advancements in technology, it can also reveal insights into a person's susceptibility to diseases, legitimacy of birth, predispositions to certain behaviours, and sexual orientation. These insights are the crux of all controversies in regards to DNA databases. The growing number of DNA profiles in CODIS and NDA have sparked fear amongst privacy activists who are concerned that DNA profiles may be leaked to the public by accident or even intentionally. In such a scenario, the use of genetic discrimination by institutions such as governments, employers, schools and banks may be inevitable. This will result in adverse repercussions.

For example, if insurers are privy to DNA information, they may be able to determine whether an individual is susceptible to certain diseases. This may lead to discrimination by charging certain individuals exorbitant premiums, or even refrain from insuring that individual. I believe people will be suspicious of the insurance institutions, which may in turn hurt both the insurance industry and the health care industry as hospitals may face a shortage of patients. Hence, the damaging effects of DNA profiles falling into the wrong hands can be overwhelming. There are concerns regarding the regulations that allow law enforcers to obtain and retain DNA samples from suspects. Law enforcers in the UK are given the right to demand DNA samples from all arrestees. This meant that DNA samples were taken from people who committed only minor offences like traffic violations and will be recorded in NDNA.

In the past, the US states used to collect DNA only from convicted criminals to be checked in CODIS for matches with cold cases. Today, all 50 states collect DNA from arrestees regardless whether they are innocent or guilty. Innocent people who are wrongly booked for offences are required to take a buccal swab. The loosening of regulation governing DNA sampling has significantly increased the number of profiles in CODIS and NDNA. Thus this exacerbated the concerns regarding privacy issues. Another issue lies in the authorities' policy of retaining DNA samples from both the guilty and the innocent. In 2009, about 150, 000 innocent people in the UK had their DNA records stored in NDNA even though they were cleared of all felony charges years ago. This practice eventually cost a British lawyer her job when a work

related security check revealed that her DNA profile was still stored in the NDNA even though she was acquitted of a forgery charge. This is an example of how poor management of DNA databases has affected the lives of innocent people.

Furthermore, the disproportionate data of racial profiles in both CODIS and NDNA have also sparked accusations of police being prejudice towards certain races which make up bulk of the DNA profiles in these databases. In the UK, inquiries had been made in regards to the African race making up 40% of DNA profiles in NDNA. This represented 77% of the black male population in the UK; which was alarming to black UK citizens. In the US, bulk of DNA profiles in CODIS is made up of African-Americans and Hispanics. These racial disparities have led to accusations of police racism in both UK and the US; and have resulted in a lack of trust in law enforcers by these ethnic groups.

Reflections on the Controversies of DNA Fingerprint

While researching and assimilating the material regarding PCR and STR methods, I am convinced that DNA fingerprinting technology is a great tool to use in forensic science. Nonetheless, I see loopholes in using DNA fingerprint per se to convict criminals. Strict rules may be established to govern the collection of DNA at crime scenes, or even implement harsh consequences to criminal investigators who fail to follow the proper rules of evidence collection (E. g. Demotion, Loss of job), however accidents are unavoidable. Even the most cautious criminal investigator or lab researcher is not free from fallibility. Therefore, I personally believe DNA fingerprinting

cannot be used alone without the help of other methods of forensic analysis such as image-capturing, fingerprinting or other forms of biometric tools.

In addition, since the rules of evidence collection establishes that DNA collected from a crime scene cannot be used in the court of law if the collection of evidence is not done properly; then there is a high possibility for wealthy high-profile suspects to bribe law enforcements into deliberately tainting evidence at the crime scene. Many have hypothesized that O. J. Simpson or Malaysian opposition-leader, Anwar Ibrahim have done this to escape their respective charges. Whether or not these accusations are true, the rule of evidence certainly makes such bribes plausible. There is also the need for proper management of the DNA database. I personally disagree with the US and UK policies of withholding of DNA data even though arrestees have been cleared of all charges. It is unjust to keep the DNA data of the innocent if comparisons with DNA samples of cold cases have revealed no positive matches.

Laws should be implemented to ensure all data of the innocent are destroyed within a reasonable period of time upon acquittal of all charges. Keeping the DNA sample of innocent people only increases everyone's suspicion towards the law enforcement's motivations for storing the DNA data. On the other hand, the issue of disproportionate DNA profiles of certain ethnic groups in DNA databases is a rather touchy issue. My suggestion to solve this is to probably not allow the viewing of aggregated DNA data based on racial groups. In fact, it might be more meaningful to show the number of

DNA samples of convicted felons in a particular state or geographical sector rather than racial numbers; which stirs unnecessary accusations of racial prejudice.

Future applications of DNA Fingerprint

In 2007, there was a radical suggestion in solving the issue of disproportion races in DNA databases. Lord Justice Sedley, an English judge of the court of appeal, suggested that everyone should have their DNA samples included in a database. He cited that this will improve the efficiency in criminal investigations and also stifle the issues of racial prejudice. However, is it possible to have a population DNA database in the future? Who should have the responsibility in storing these confidential data? I don't see why this responsibility be given solely to the law enforcements when healthcare industries can help society by using the information to predict the susceptibility of diseases in individuals. Then maybe a governing body consisting of key officials from various industries should be in-charge of the database collectively? It is difficult to find a suitable party to ensure the safety of such rich information. I believe even a third party custodian would not be suitable.

We have seen one too many corruption cases involving high-level government and police officials to be rest assured that whoever is appointed can be tasked in ensuring the information is kept confidential. Even if a suitable trustee is identified, can the data be safe from attacks? I foresee the DNA database will be the prime target for hackers around the world. Till

today there is no database that is 100% hack proof. Thus, it is extremely difficult to find a suitable trustee who can ensure that the data does not fall into the wrong hands. Apart from this issue, I feel that the population DNA database will create chaos in certain industries. One example I have highlighted earlier is the insurance and healthcare industry, I shall now look at it from the healthcare industry's point of view.

We agreed that the DNA information should not be privy to the insurance industry but it may be advantageous to the healthcare industry if we look at the prospects of its uses in identifying individuals who are prone to certain life threatening ailments through their DNA. However, these identified individuals would then be aware of their impending health risk. This might result in a mad-rush by these individuals to purchase insurance so as to ensure that the medical costs to treat their impending ailments will be fully covered. But since the insurance industry cannot identify who is susceptible to diseases, they will eventually have to pay the huge insurance pay-outs to these identified individuals. This may cause the collapse of the whole industry.

Hence, based on my earlier example and this example, both industries might be thrown out of kilter if a population DNA database is established. Maybe certain measures have to be in place, for example: restricting an individual's ability to purchase insurance after being identified as a person of significant health risk, but this would mean that only the rich would benefit. Therefore, whatever the measures implemented, not everyone will benefit which defeats the purpose of having the DNA database in healthcare. Lastly, I

predict that the planting of DNA at a crime scene by criminals will cause huge problems to the police. With a population DNA database, and the over reliance on DNA to solve crimes, criminals may plant DNA of multiple innocent people at a crime scene to send investigators on a 'wild goose chase'. It is easy to take hair samples or saliva samples from people; within the time I took to type this paragraph, I have already thought of several creative ways of obtaining DNA samples from strangers.

As investigators can identify every individuals' DNAs that have been planted based on the population database, a long process of investigations and interrogations of multiple individuals may ensue. Therefore, instead of increasing the efficiency of the police force as proclaimed by Lord Justice Sedley, I believe a population DNA database might reduce the efficiency of the police force inadvertently.

Conclusion

To conclude, there are a lot of controversies regarding the storing of DNA fingerprints. However, despite all the issues regarding DNA fingerprint print, it is still the best tool in forensic analysis in today's context. As for now, the onus is on law enforcers to ensure the proper management of databases and ensuring the confidentiality of their databases. In regards to the feasibility of a population DNA database, after much cogitation, the idea of a population DNA database seems more of a bane than a boon. Many issues seem insurmountable. Maybe technological advances in the future can help to resolve security issues regarding the safe keep of DNA databases. However,

there have been interesting studies in recent years that suggest the inability for DNA to predict the susceptibility of diseases. If these findings are true, it would assuage most of the concerns and controversies. Then maybe the idea of a population DNA database can be implemented after all.

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