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# DNA Fingerprinting

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# **DNA FINGERPRINTING**

An Interactive Qualifying Project Report

Submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

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## **ABSTRACT**

This IQP analyzed DNA fingerprinting technology. The considerable breadth of the field was subdivided into the scientific, procedural, legal, and ethical aspects of the technology.

Different procedures of DNA analysis, including RFLP and PCR, and the progression from analysis of VNTRs to STRs were discussed. The methods used for collecting, handling, storing and processing forensic evidence were enumerated. The development of legal precedent to permit the use of DNA evidence in the courtroom was reviewed with particular emphasis for landmark court cases and the evidence assessment systems set forth by presiding judges. The ethics of DNA databases with relation to informed consent for taking DNA samples, public discourse about the pitfalls of DNA fingerprinting, privacy rights in relation cold-hit techniques such as familial and phenotypic inferencing, as well as retention of DNA samples, and the use of private corporations to analyze DNA fingerprints were examined.

# TABLE OF CONTENTS

Signature Page	1
Abstract	2
Table of Contents	3
Project Objective	4
Chapter 1: DNA Fingerprinting Types and Applications	5
Chapter 1: Bibliography	20
Chapter 2: DNA Forensics	21
Chapter 2: Bibliography	32
Chapter 3: Landmark DNA Court Cases	33
Chapter 3: Bibliography	52
Chapter 4: DNA Database Ethics	56
Chapter 4: Bibliography	119
Conclusion	126

## **PROJECT OBJECTIVE**

The objective of this project was to examine DNA fingerprinting technology in all of its aspects, and analyze the ethical and social implications it carries. DNA fingerprinting has revolutionized forensic investigations, and has even extended its reach to the point where it can solve cold cases. Though DNA fingerprinting is now nearly universally accepted in legal proceedings when the collection and analysis is performed correctly, the forensic use of DNA databases causes intense ethical controversy. This IQP discusses how ethics play into DNA technology and investigates privacy of individuals weighed against its usefulness to society as a whole. Overall, DNA fingerprinting allows us to be more confident in our prosecution of the guilty and exoneration of the innocent, while opening up many possibilities with the potential to revolutionize anthropology and create new avenues of genetic therapy.

# **Chapter 1: DNA Fingerprinting Types and Applications**

Molecular Biology is one of the fastest growing sciences, especially since the discovery and implementation of DNA Fingerprinting. This technology allows us to examine minute differences in DNA sequences between two individuals, allowing a multitude of information to be discovered and harnessed. From genetic therapy research, to enhanced criminal investigation, to wildlife management; DNA profiling has enabled all of these fields to be explored and developed with an accuracy that could not be achieved with other techniques. The purpose of this chapter is to introduce you to this new technology, discussing the main ways a DNA fingerprint is obtained, and some of its main uses. This chapter lays the groundwork for subsequent chapters discussing the impact of the technology on society.

## **Introduction to DNA**

So what exactly is DNA? Deoxyribonucleic acid (DNA) contains the genetic information within the cells of all living organisms, including humans. The information DNA holds is like a blueprint for the human body; it contains the ‘instructions’ necessary to construct all cell components like protein and RNA molecules. These regions of our DNA that encode RNA and proteins are called genes. Other regions of DNA sequences provide information needed for gene regulation, or encode absolutely nothing. Different versions of each gene sequence are called alleles, and these differences are what is analyzed in DNA fingerprinting. The specific location a given DNA sequence on a chromosome is known as its locus. Currently, thirteen core loci are analyzed in a standard U.S. DNA analysis.

Most DNA is held in the cell nucleus and is called nuclear DNA; however some DNA is also held in the mitochondria in the cell's cytoplasm, and is called mitochondrial DNA (mtDNA). Physically, DNA is comprised of two polymer strands of nitrogen bases attached to sugar and phosphate groups (Figure-1). The bases are attached to the sugar molecules, and the bases join in between each strand to create a ladder structure. This ladder coils to form the unique shape of DNA, the double helix.



**Figure 1: Diagram of the Structure of DNA.** Shown is the double helical structure of a short length of a DNA molecule. Blue and orange represent the two helices, while green, yellow, pink and light blue denote bases (What does DNA look like?, 2008).

The entire unit of a base, a sugar, and a phosphate molecule is called a nucleotide. When two nitrogen bases join together by weak hydrogen bonds (shown as rungs of the ladder in Figure-1) they are called a base pair. A base can be one of four nitrogen bases: Adenine, Thymine, Cytosine, or Guanine. The nucleotides bond forming the ladder 'rungs' of DNA, however only Adenine attaches to Thymine, and only Cytosine attaches to Guanine. The vertical sides of the ladder (shown as blue and orange in Figure-1) are formed from alternating sugar and phosphate molecules with a nitrogen base connected to each sugar.

An important feature of DNA is its ability to replicate itself, which needs to be done each time a cell divides. This process of DNA replication is also important when using the amplifying type of DNA fingerprinting. The DNA splits itself in two by 'unzipping' like a zipper splitting

the base pairs at their weak hydrogen bonds, so in the end there are two single polymer strands that can serve as templates for adding new nucleotides. After the sides have split, each side connects with the free floating nucleotides (C, T, A, and G bases). When complete, there are two complete double strands of DNA. DNA is packaged into chromosomes; the DNA strands are coiled and compacted into X shaped objects.

### **DNA Fingerprinting Introduction**

DNA fingerprinting is one of the most useful technologies that has spawned out of DNA and genetics research so far. DNA fingerprinting, also known as DNA typing or DNA profiling, has a variety of applications, ranging from aiding in criminal investigations to wildlife management. DNA typing can be performed in several ways depending on what sort of information you are looking for in your samples. Essentially, DNA profiling is an identification process based on genetic information. Every creature, excluding identical (zygotic) twins, triplets, and so on is genetically distinct. DNA Fingerprinting can be used to match a sample to a known source, compare two samples to see how similar they are to determine relatedness, check the compatibility of biological transplants, aid in plant breeding, identify skeletal remains, and help breeding programs in zoos and animal reserves. Only a very small sample is needed to analyze DNA, for example, commonly DNA is collected from an individual by obtaining a blood sample or a skin cell sample using a cheek swab.

DNA profiling was first used in England by law enforcement in the mid 1980's, immediately following its discovery by Alex Jeffreys (Jeffreys et al., 1985a; 1985b). The United States began employing DNA typing in 1987 to aid in criminal investigations, in a series of landmark cases that will be described in Chapter-3. One of the most well known cases where



DNA played a role was the O.J. Simpson murder trial in 1995. In spite of large volumes of blood evidence matching OJ at the crime scene, his home, and his car, the evidence was disputed in court due to the possibility of tampering or contamination, so these important forensic procedures have since received a lot of attention, which will be discussed in Chapter-2.

DNA evidence was also used in the Bill Clinton- Monica Lewinsky scandal in 1998. Here, the now famous evidence left on Lewinsky's dress by Clinton was properly collected and stored, and its analysis confirmed suspicions that Clinton and Lewinsky had an inappropriate relationship. Since these cases, DNA evidence has helped in innumerable investigations across the globe. DNA profiling techniques have come a long way in the past twenty years, and we now have faster, easier, and more effective ways of analyzing this information.

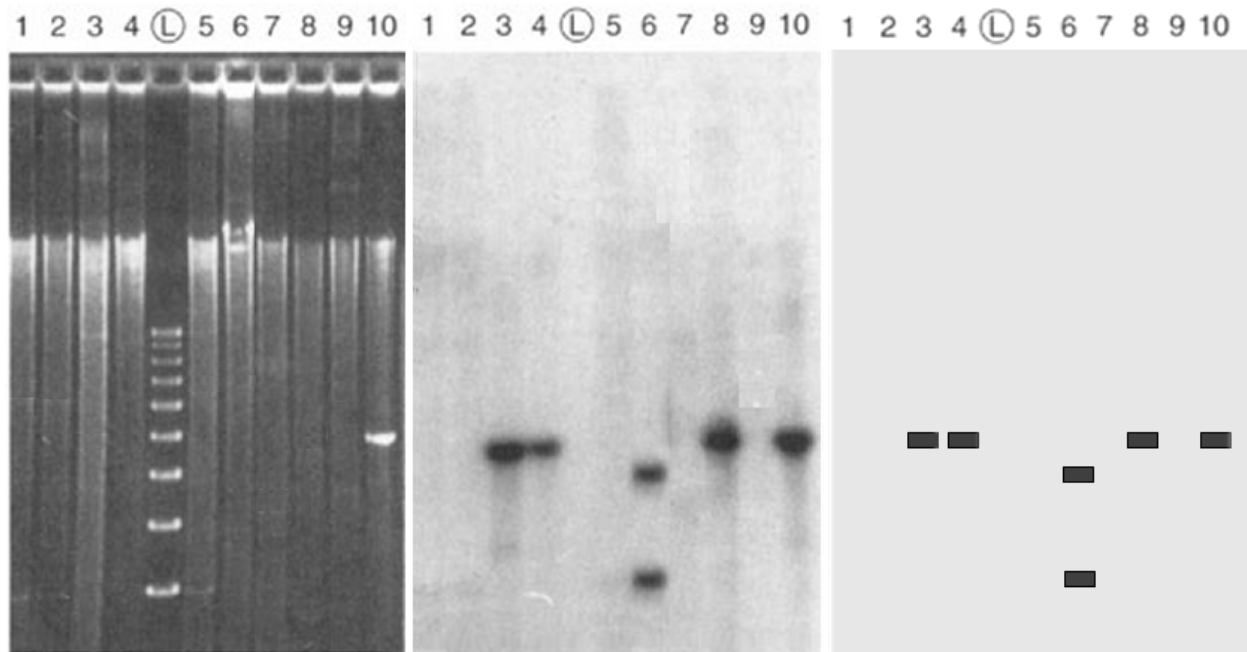
### **DNA Fingerprinting Types**

There are two main methods for DNA fingerprint analysis: non-amplifying (RFLP-type) and amplifying (PCR-type).

#### *RFLP-Type DNA Analysis*

One of the first methods discovered for DNA analysis was Restriction Fragment Length Polymorphism analysis (RFLP). The technique was discovered by Alex Jeffreys in 1985 (Jeffreys et al., 1985a; 1985b), and is based on a previous Southern mapping procedure. "An RFLP is a sequence of DNA that has a restriction site on each end with a "target" sequence in between" (Davidson College, 2006). Specific DNA sites (loci) are chosen for analysis which produces fragments of different lengths between individuals. A restriction enzyme is added which cleaves the DNA into pieces at specific sequences. The produced DNA fragments are

then sorted by size using gel electrophoresis which arranges the pieces by molecular weight. Once sorted, the DNA is transferred to a blotting paper (Southern blot) while retaining the same arrangement they had on the gel. Next, the fragments on the membrane are incubated with a radioactive probe which will bind only to the target sequence, marking its location on the DNA polymers. The probe is detected by incubating it with an enzyme that will give it color or light which will show up on an x-ray film. Once the x-ray is taken we can see where the polymorphism (different fragment length) is located in each sample of DNA (Figure-2).



**Figure 2: Example of an RFLP-Type DNA Fingerprint.** [Left] an electrophoretic gel stained with ethidium bromide to visualize the DNA. Note that with all the DNA visualized, it appears as a smear, not discrete bands. [Mid] Southern Blot autoradiogram; this is the part of the blot exposed to the DNA probes to visualize only specific DNA bands. [Right] A schematic interpretation of the DNA band pattern of the middle panel. (Carr, 2000)

Using this technique we can determine if two samples have come from the same individual, or if they are unrelated. Being one of the first techniques to analyze DNA, RFLP

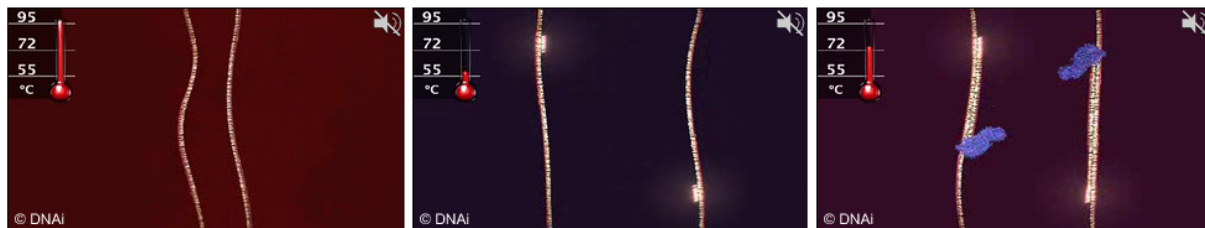
technology has some problems associated with it: it is slow, and it requires a relatively large sample of DNA. In some cases, it can take up to a month for results! However the advantage of RFLP analysis is it is less prone to contamination than PCR, so this technique is often used as a backup technique when contamination is suspected in the faster PCR analysis.

### *PCR-Type DNA Analysis*

The second main method for DNA fingerprint analysis is polymerase chain reaction (PCR). This technique is much faster than RFLP, and can be performed on smaller DNA samples, but it is prone to contamination. PCR is one of the most widely used techniques in molecular biology. PCR is a procedure used to amplify a specific section of DNA so that subsequent DNA fingerprinting procedures can be performed. PCR can generate millions of copies of the sample in a matter of hours within a test tube. This allows for more extensive testing to be done on a small amount of collected genetic material, and also allows for a DNA profile to be obtained in as little as two days.

To perform PCR on a sample you must know a small portion of the DNA sequence to be replicated. In order to isolate that sequence, short primers are made that will anneal to the very beginning and the very end of the area of interest (or just outside of the start and end). The primers are simply a complementary sequence of base pairs about 18-20 bases long that match up to the outer ends of the region of interest. The DNA double helix is heated to 94°C (just underneath boiling) which allows the DNA strands to unwind and separate into single stranded DNA (Figure-3). This step is called denaturation. The mixture is lowered to 54°C in a step called annealing. As the reaction begins to cool, the primers that were made previously are added to the mix, and when they find their complementary sequence on the single stranded DNA

the primers bind to them. Once a few of the primers have bound to the single stranded DNA, Taq polymerase is added to the solution to begin to build up the rest of the DNA sequence beginning from the primer. Lastly the temperature is raised again to 72°C in the phase called extension. Here the polymerase works to bind the free floating nucleotides (A, T, C, and G) to the DNA properly matching the base pairs; A to T and C to G.



**Figure 3: The Three Main Stages of PCR.** [Left] DNA denaturation at 94°C. [Middle] DNA annealing at 54°C. [Right] DNA elongation at 72°C. (The cycles of the polymerase chain reaction, 2008)

This DNA replication process gets repeated many times over several hours to continually build up the area of interest in the DNA sample. In some PCR applications, the final reaction is simply analyzed on a gel to determine the length of the DNA band amplified, its length determines which type or allele the person has.

## SNPs

Single nucleotide polymorphisms (SNPs) are single base (either, A, T, C, or G) alterations in an individual's DNA sequence at a particular location. "For a variation to be considered a SNP, it must occur in at least 1% of the population. SNPs, which make up about 90% of all human genetic variation, occur every 100 to 300 bases along the 3-billion-base human genome" (SNP Fact Sheet, 2004).

Two thirds of the time, an SNP will involve Cytosine being replaced with Thymine. Though SNPs do not seem to alter major functions of the human genome, they may greatly affect how people respond to different diseases and medications. For this reason SNPs are of high interest to biomedical researchers in furthering medical diagnostics and pharmaceuticals for certain ailments like cancer, diabetes, and mental illnesses. SNPs can be analyzed several ways. Hybridization of complimentary DNA probes is a common method to examine SNPs. In this case, if the DNA sequence does not hybridize to the probe under high stringency conditions, the sequence likely has a SNP relative to the probe. Other techniques use melting point temperatures to breakup mismatched nucleotides in the probe versus template DNA. PCR is often used along with hybridization methods to amplify the amount of signal measurable, since SNPs only involve point mutations. In this case, the PCR primers are designed to bind to the SNP region, if they don't bind due to a mismatch, no PCR product is formed. RFLP methods can sometimes be used to analyze SNP data, however PCR is more practical and faster than other methods.

## **VNTRs**

DNA profiling can also be performed by analyzing Variable Number Tandem Repeats (VNTRs). “VNTR analysis was introduced to overcome some of the disadvantages of RFLP analysis. The principal advantage of VNTRs is their enormous variability, which increases their discriminatory power.” (Collins, 2002). VNTRs are randomly repeated regions of nucleotides 15 to 50 base pairs long that are hereditary. However, VNTRs often repeat for a long stretch on the human genome, making them more appropriate for RFLP analysis than PCR analysis. VNTR profiling was once the preferred DNA fingerprinting technique as it was more accurate and

useful, however with the discovery of SNPs, STRs, and PCR methods, VNTR analysis has become less common for the majority of DNA profiling needs.

## **STRs**

Short tandem repeat (STRs) polymorphisms are another type of variation in the human genome that can be analyzed to obtain a DNA profile. STRs are short sequences of DNA about 2 to 5 base pairs that repeat many times adjacent to one another, typically within the non-coding region of DNA. STRs are examined by measuring the number of repeats of a certain STR sequence at a specific locus. This allows a genetic profile to be made of the individual being tested. STR analysis came to be popular in the 1990's and is the most widely used method in criminal investigations because it can rapidly be analyzed by PCR. Polymorphisms shorter than STRs, like SNPs, are more susceptible to damage or degradation. But repeats of 4 to 5 nucleotides long are ideal for accurate testing as they have the ability to withstand imperfect conditions, and shorter repeats like STRs are ideal for PCR amplification. The Federal Bureau of Investigation currently analyses STRs at thirteen core loci on the human genome to determine DNA profiles.

## **Y-Chromosome and Mitochondrial DNA Testing**

Two common targets for DNA testing methods are Y-chromosome analysis and Mitochondrial DNA analysis. Y-chromosome analysis is often of use when looking for relations among males. This chromosome is passed directly from father to son, so analyzing sequences on this gene can determine relatedness or can help to discriminate between male DNA samples.

Paternity tests can also utilize Y-chromosome analysis when testing for the parentage of male offspring.

Mitochondrial DNA (mtDNA) is found in the mitochondria of our cells. Nuclear DNA must be extracted from relatively recent samples (DNA Forensics, 2006), but mtDNA analysis can be used on old samples like bone and hair, which no longer have cells with nuclei but do contain mitochondria. This technique is useful for older or unsolved cases where nuclear DNA may not be intact or available. Also mtDNA analysis is useful in anthropological studies as the genetic material is maintained for long periods of time and it does not have as much variation as nuclear DNA. Mothers provide mtDNA to all of their offspring so family lines can be followed through the female members far more easily than following the nuclear DNA which is greatly altered with each new generation. Populations of ancient civilizations can be tracked using mtDNA by finding the related persons in a family line and determining how old the samples are.

### **Applications of DNA Fingerprinting**

DNA Fingerprinting has become one of the most useful applications in molecular biology and biological research. “Since the first forensic use of DNA fingerprinting in 1987, the technology to analyze an individual's genetic profile has become more sensitive, easier and cheaper to use and more widely available” (Collins, 2002). Forensic investigation, genetic counseling, genetic therapy, disease detection, selective plant breeding, captive breeding programs, paternity testing, transplant compatibility, identification of remains, and anthropology were all able to progress due to the advances in DNA typing.

## *Criminal Investigations*

Criminal investigations have taken on a much more accurate approach since DNA fingerprinting was developed. Before DNA could be analyzed, the only way to differentiate biological evidence was by blood type. But blood type was not a very discriminatory piece of evidence and therefore could easily lead an investigation in the wrong direction. “In criminal investigations, DNA from samples of hair, bodily fluids or skin at a crime scene are compared with those obtained from suspected perpetrators” (DNA Fingerprinting: Other Uses, 2003). Not only can an individual be identified from their blood sample, other biological samples can also be examined and tied to their sources. This leads to better confirmation and exclusion for suspects in a case. DNA typing is so reliable now, that databases of DNA profiles of criminals are being made to identify these people if they are involved in other crimes. CODIS (the combined data index system) is the countrywide database used in the United States to document the DNA fingerprints of different felons. CODIS contains two individual indexes; the first is of the DNA profiles of convicted offenders who committed sex crimes or other violent crimes. The second index contains the DNA profiles that are collected as evidence at crime scenes. CODIS stores DNA Fingerprints that have been generated with STR analysis. All local, state, and federal investigations submit their DNA information into CODIS making it the largest DNA database in the world. When a DNA sample needs to be matched, it is entered into CODIS and the database is automatically searched for a matching profile.

As will be discussed in Chapter-4, depending on the state, laws differ concerning which criminal’s DNA profiles are kept in CODIS. However as DNA typing has become more advanced and more samples are collected, there is a backlog of samples waiting to be analyzed and submitted into CODIS. DNA typing not only helps convict criminals of crimes, but it also



helps to exonerate the innocent. Once DNA Fingerprinting was developed it allowed for old cases to be reevaluated, and some individuals were released from jail as they had not committed the crimes they were serving time for.

### *Parental Testing*

“Excluding criminal investigation, the principal use of DNA fingerprinting is parentage testing” (Collins, 2002). Paternity or Maternity Identifications Tests have become readily available since the development of DNA Fingerprinting. These tests are performed when the mother or father of a child is unknown or is being disputed. Most often it is the paternity of the child that is unknown, but with new developments in fertility procedures there are more cases where the maternity of a child needs to be determined. Cases involving adopted children, hospital mix-ups, *in vitro* fertilization, and surrogate mothers may require maternity testing. Before DNA typing was available, paternity was analyzed by examining congenital traits like attached earlobes and widow’s peak, as well as ABO blood typing, or the analysis of individual proteins and enzymes. DNA fingerprinting has overcome these other techniques for its undisputed 99.999% accuracy when samples of the mother, child, and two disputed fathers are available. Typically thirteen loci are examined, and if 7 of the loci share alleles between the parent and child samples they are said to be biological parent and child.

### *Molecular Archaeology*

Another application of DNA Fingerprinting is Molecular Archaeology. This branch of archaeology uses old samples of DNA or mtDNA to discover information about past civilizations. Human and animal bloodlines can be followed; migration and traveling patterns

can be determined, and even cultural practices of civilizations can be determined by using DNA analysis. DNA material can be obtained from a variety of old sources such as “biological remains, skeletal remains, body tissues, hair, teeth, and in some cases fossils” (Christianson, 2000). However, with archeological material there is more chance that the samples may be damaged or degraded. Hot and humid climates tend to be the worst conditions for preserving genetic material, whereas cold and dry climates tend to be the best, as is the case of the “Tyrolean Ice-Man” which was discovered in the Alps.



**Fig 4: Photo of the Tyrolean Ice Man.** This 5000-year old individual’s DNA has been analyzed placing him in a Northern European population (Landis, 2008).

Extraction of DNA from archaeological samples is somewhat different than fresh samples. Either UV radiation or a chemical process is used to break down the sample while allowing the DNA to remain intact. The DNA is then isolated and then amplified by PCR to make analysis easier. Sometimes mtDNA needs to be used when nuclear DNA cannot be obtained from the sample. DNA technologies have allowed us to examine ancient civilizations

in ways, and with an accuracy, that we would not be able to achieve otherwise. As these methods continue to be developed, more will be discovered about the past and our ancestors.

### *Wildlife Management*

A relatively new application of DNA typing is Wildlife Management Forensics. With DNA typing technologies, it is now possible to follow poaching cases, endangered species trafficking, and the use of endangered species in products. “Previously, prosecuting someone, say, caught with chopped up meat, could get difficult as the electrophoresis test employed could only tell what animal species it was but not where it originated” (Li, 2007). DNA fingerprinting can be employed to ensure zoos are not illegally obtaining wild animals, and that only captive bred animals are being traded between zoos. Another application in wildlife management is the detection of new species. With DNA fingerprinting more species can be discovered by finding the small differences between species though they may look alike physically. Captive breeding programs are also benefitting from DNA applications, as the analysis of the potential parent’s genetic makeup are possible, allowing for healthier offspring.

Though DNA fingerprinting as a whole has allowed many great advances in science and criminal investigations, there are still some limitations and problems with the current system. Ethically there are many concerns surrounding this technology. Should everyone’s DNA be documented in a database? Who should be allowed to access this information? Do individuals ‘own’ their genetic information? Also, how far are we going to allow reproductive genetic technologies to be developed? These are a few of the ethical questions that have been raised concerning DNA profiling that need to be considered by society, and some of these questions will be addressed in detail in Chapter-4. Certain genes have been discovered that predispose

individuals to diseases such as cancer, diabetes, and Alzheimer's disease, so many people are concerned this information will be present in the database, or at least resides with the original DNA sample. However this type of medical predisposition data is not present in CODIS. With respect to non-criminal type DNA testing, fortunately the Genetic Information Nondiscrimination Act (GINA) was enacted this year to protect individuals from being discriminated against by insurance companies and employers if they choose to have their DNA tested for certain diseases.

DNA fingerprinting has allowed molecular biology to be developed to lengths we could not have imagined previously. As this technique is developed further into new applications, we will only discover more about the human genome and how we may be able to harness that knowledge to aide humankind. In the years to come, advances in gene therapy and disease detection are sure to be one of the most researched areas involving DNA analysis, and will hopefully yield breakthrough information. We cannot predict what this research may lead to, or how many mysteries may be solved, but we can tell from its growth in the past twenty years that DNA fingerprinting applications in the years to come will offer similarly exciting wisdom.

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## **Chapter 2: DNA Forensics**

The collection and utilization of DNA evidence in the judicial system today has become somewhat of an art form. If done properly, this evidence can place a specific person at the scene of a crime which is a vital cornerstone in building a court case. When done improperly, it can lead to both the release of dangerous criminals back into society and public doubt in their local or federal law enforcement agencies. Needless to say, it is of vital importance that the forensic scientists of the present and the future must practice carefully drawn out guidelines to ensure lawful and accurate results in all case files. In 2000, the United States government did just that by creating a US Department of Justice Handbook. This booklet has become an invaluable tool; it maps out the entire procedure for a law enforcement agent or a forensic scientist to properly handle a crime scene from securing the area, to how to properly preserve evidence from outside contamination.

### **2.1 How to Properly Handle a Crime Scene to Preserve DNA Evidence**

#### *2.1.1 The Role of the Initial Responding Officer(s)*

The first law enforcement officer to arrive on the scene of a crime has probably the most important job of all, completing a laundry list of items that are all vital in crime evaluation and case building. The first and most essential thing that must be ongoing throughout the assessment of the crime scene is to ensure that it is safe for anyone, including themselves, to be in the area. Thus the first officer to respond secures the area as quickly and efficiently as possible to avoid any outside contamination of the evidence present at the scene. They must remember two things at all times during this procedure, always treat the area as a crime scene, and follow the

assumption that the crime is still in progress until either it is proven otherwise (US Department of Justice, 2000). They must also register important information like date, time, location, type of crime committed, and people involved in the crime, while also remaining alert for any people leaving the scene; these people could be possible suspects attempting to flee. Next they must evaluate the entire crime scene to search for details such as people in the area that might have been involved in the offense, along with any other minor violations that have also been committed in the vicinity (US Department of Justice, 2000). Throughout this entire process the officer must remain alert, observant, and cautious to avoid any further incidents and to guarantee the safety of everyone in and around the crime scene.

Using the powers of observation and good judgment, the first officer to arrive on the scene is obligated as a public defender to ensure the safety of everyone around the area where the crime has been committed. The best way to describe the proper actions to be taken in order to prevent harm to anyone else on the scene is that the officer must “approach the scene in a manner designed to reduce risk of harm to officer(s) while maximizing the safety of victims, witnesses, and others in the area” (US Department of Justice, 2000). To do this, one must overlook the area and identify anyone who is a threat to the rest of the public around and neutralize them. Then identify any other threats to other law enforcement arriving on the scene and contact the proper authorities for defusing the particular situation, e.g. if there are chemical threats present, contact a hazmat team and allow them to clean up before entering the scene. Lastly, this first arriving officer should call for any other necessary assistance and contact their supervisor before proceeding.

Ensuring the appropriate medical attention gets to victims, bystanders, and yes even offenders, is another key job that the first officer to arrive on the scene must fulfill while

protecting emergency personnel from harm and also preserving the crime scene for DNA evidence. This process requires this official to direct the medical personnel around the area to guarantee their safety and preserve the crime scene from unnecessary contamination, instruct them to keep the victim's or victims' clothes intact and sustain the smallest amount of contact possible with their clothes and belongings, and make sure there is no clean up or removal of any objects in the crime scene.

With the safety of others taken care of, it is time to begin building a case which starts with a lot of documentation of evidence right there at the crime scene. Get statements for all victims, witnesses, and possible suspects, record down emergency personnel's information such as their names, phone numbers, and addresses, including that from any victim's they have already taken away, have an officer accompany all victims to the hospital and have them acquire the same information (US Department of Justice, 2000).

Now that the safety of everyone in the area has been guaranteed the officer must now define and secure the boundaries of the crime scene. The boundaries can be identified as possible exits and entrances to the scene for witnesses and offenders, the entire area that the crime could have actually occurred in, and any place the victim could have been moved to and from; they must also set up tape, rope, or cones to cordon off these areas (Byrd, 2000). Other tasks needed to be completed are searches with the proper warrants, documentation of all persons entering and exiting the area, preventing all people in the area from doing anything to leave their DNA at the scene, like eating, drinking or smoking, and noting the original location of the victim when they first arrived on the scene. In the case of possible evidence, protection from the weather must now be taken into account like rain and wind (US Department of Justice, 2000).



All people at the scene of a crime when the first officers arrive fall under three categories, suspects, witnesses, or bystanders. An additional responsibility of these officers is to determine which person is which, separate them from each other, and put them in a safe location for questioning; bystanders must be completely removed from the scene (US Department of Justice, 2000). An unfortunate incident that may occur is the arrival of family or friends of any of the victims. It is important to restrain them with as much compassion as possible, for the purposes of keeping unnecessary persons or personnel off of the crime scene to avoid contamination of DNA evidence. Other examples of this would be the media, lawyers unrelated to the issue, and politicians. As always the officer must minimize the damage and contamination of evidence during these proceedings.

The last responsibility is to turn over control of the scene to a superior officer or department and assist them in any way that they can until off duty or relieved. Give them all documentation taken since their arrival and brief them on all boundaries, evidence, witnesses, and possible suspects (Handbook for Forensic Services, 2007).

It can be easily deduced that the overall responsibility of the first arriving officers is to ensure the safety and health of all people at the scene including victim's, witnesses, bystanders, fellow officers and emergency personnel, and suspects, while minimizing the risk of contamination of all the DNA evidence at the scene of the crime. These measures must all be taken to prevent any further harm from occurring to the community and to preserve the crime scene as much as possible for the appropriate authorities to evaluate.

### *2.1.2 The Role of the Investigator*

Now that the crime scene is under the supervision of an investigator, the process of properly evaluating and collecting evidence can begin. First, the supervisor must reevaluate the entire crime scene including the boundaries, all of the evidence, all safety issues, and the entrances and exits to ensure that the proper procedures were taken since the crime was discovered. It is best to also create a main entrance and exit to easily document who exactly is making their way on and off the crime scene and their purpose there. This way the investigator will later have an idea of who was doing what on their scene; an investigator should always have total control over the area in order to preserve all the evidence. Now the investigator must also determine the number of crime scenes that are present and separate them for individual processing and prioritizing. When the time comes, all the necessary items that must be documented include photos of the victim, murder weapon(s), and the surrounding area along with the ID of the victim, witnesses, and suspects (US Department of Justice, 2000). Other types of evidence that need to be documented are forensic biology such as any types of bodily fluids, hairs, or skin samples, impressions like shoeprints, fingerprints, and tool marks, or trace evidence including fibers, broken glass, and gunshot residue (Byrd, 2000). All of this evidence must be kept in a secure location nearby the crime scene for evaluation and protection from tampering.

Next, it is important to conduct a walkthrough while recording all information necessary for the case so that there is a hardcopy for any and all investigators who may need it to build on any theories. This walkthrough will allow the on-scene investigator to acclimate himself to the situation, while observing the evidence, the victim, and speaking with witnesses and suspects (US Department of Justice, 2000). Also it will provide a permanent record of all the evidence provided for any superiors to read while the case is forming.

### *2.1.3 Processing the Scene*

The investigator is now familiar with the crime scene and has received all the information noted by the other officers that were the first to arrive at the scene, now the investigator must take all this information and decide what types of specialized personnel and equipment to have sent down to the scene to appropriately collect and evaluate the evidence. Expert forensic teams specializing in blood spatter analysis, ballistics, photography, and evidence collection are all experts in different parts of the field of forensic scientists that an investigator would have at their disposal (US Department of Justice, 2000). It is up to them to make to right decision and call only the teams needed for processing the crime scene because unnecessary personnel at the scene could lead to confusion or contamination of DNA evidence that could be useful in solving the case.

Now that the necessary specialists have been called upon, the real search for DNA evidence can begin, one of the best ways to start is to take DNA samples from the first responding officers and place them in the “elimination samples” category to prevent the use of incorrect DNA evidence in the case (President’s DNA Initiative, 1999). While the search is taking place, clean and sanitary practices and tools must be used at all times during the process of identifying, removing, and analyzing the evidence. Some samples of DNA are tiny, even microscopic, and if they are contaminated in any way they must be thrown out, and obviously most scenes do not have an endless supply of samples. It is also a good idea to document this entire process using photography, video, precise measurements, and written records so that they may be referred to at a later time (US Department of Justice, 2000). To speed things up, prioritizing the evidence is used to allow the investigator to decide which pieces should have

more attention paid to than others. It is best to have the more qualified and recommended experts examining the evidence that is believed to yield to best results of DNA fingerprinting. All investigators have a reputation to uphold within the community, and should wisely trust only the best people with the most delicate evidence at the scene.

The last step to complete at the crime scene is moving the evidence to a more secure location so that it may be examined more thoroughly and with more sophisticated equipment. All the evidence must be handled with extreme delicacy while being recorded, packaged, labeled, and transported to the appropriate laboratories or storage unit. If this is done thoroughly and accurately, it will allow the investigators and the forensic scientists to move from item to item in the crime scene evidence catalogue with relative ease and little frustration.

#### *2.1.4 Completing the Investigation*

To wrap up the entire investigation, it is best to assemble a debriefing team to review the entire scene and the evidence found there one last time to ensure that there is nothing else to be gained from the crime scene. Included in this team are the investigators, responding officers, forensic team, and all other specialized personnel that were dispatched to the site (Handbook for Forensic Services, 2007). Topics that could be talked over are the evidence, the tests that should be run on them, and handing out the post-scene jobs to the appropriate specialists. After the walk around, all hazardous areas that are left must be addressed and dealt with to guarantee public safety.

The last step is to compile a “case file” that has on record all of the evidence, photographs, videos, diagrams, sketches, emergency medical personnel records, crime scene entrance and exit records, search warrants, initial responding officer reports, and all forensic

teams reports (US Department of Justice, 2000). This case file is a report of everything that the examined crime scene had to offer the investigators as far as evidence, witnesses, and suspects.

## **2.2 Methods of DNA Evidence Removal from a Crime Scene**

### *2.2.1 Introduction*

A forensic scientist on a crime scene has many different jobs to perform; one of these is taking a sample of DNA evidence, packing it, and preparing it for transport back to their laboratory for further study. They have several options for removing the evidence and they must make the best decision based on where the evidence is, what condition it is in, and what type of surface it lies on.

### *2.2.2 Absorption*

There are two different types of materials used by forensic scientists when performing absorption of blood from crime scene evidence; they can use either cotton squares or threads; the method is the same regardless of the material used. First the unused material must be boiled in distilled water to completely clean it out of anything that might contaminate the sample, and then it should be allowed to dry. Now it can be used to mop up, or absorb, a portion of the blood found at the crime scene and placed in a plastic container for storage (Schiro, 2001). It is important for them to never handle the material with their bare hands as this would leave traces of their own DNA on it, which would in turn contaminate any other sample picked up with it.

### *2.2.3 Tape Lifting*

For some surfaces a technique called tape lifting is the best choice, which requires the scientist to cover the entire stain and surrounding area with tape and pressing firmly down on the non sticky side. Pull up the tape and place the sticky side on a vinyl surface, which has proven to be the best surface to prevent any type of contamination to a sample (Schiro, 2001). This method has allowed scientists to easily store, label, document, and transport samples of dried blood to their laboratory for further analysis.

### *2.2.4 Scraping and Cutting*

Scraping up a dried sample of blood with a sharp object is another way to remove evidence from crime scene objects. The scrapings of blood must be stored in a paper container instead of a plastic one because when stored in plastic, flakes of blood tend to disperse and stick to the sides of the container when stored in plastic, and plastic tends to retain humidity which can hydrate a dried sample causing it to degrade (Schiro, 2001). Cutting the entire material that the blood is dried into can be used as a last resort when the bloodstain is not extracting with any other method. This process should be used last because it is much more difficult to store and preserve.

## **2.3 DNA Technology**

### *2.3.1 Luminol*

Famous for its regular usage on hit television crime dramas and documentaries, luminol is an extremely valuable tool for crime scene investigators. Its purpose is to identify areas on objects where bodily fluids were once present after either drying up or being cleaned up by the

perpetrator(s). To make luminol, a person must mix the powdered luminol with hydrogen peroxide and hydroxide into a spray bottle for easy usage. After spraying down the area, all forms of light must be turned off or blocked out while the spray reacts with the hemoglobin found in our blood, semen, or saliva causing a light blue glow to occur. Unfortunately, luminol has been found to react the same with household cleaning products that contain bleach, and it also destroys DNA upon contact, so it can't be used as evidence by itself but it can assist investigators in finding new evidence, such as the type of weapon used or a shoeprint leading to a suspect when critically studying the spatter of unknown fluid (Harris, 1998).

### *2.3.2 Temperature Storage of DNA Evidence*

When a forensic scientist is deciding what temperature to store the blood samples taken from a crime scene, the main deciding factor is which form the sample is in. For samples of blood dried on a smooth surface, it is best to keep them at room temperature, but only for a short period of time until it can be extracted. This way there is no chance for condensation to occur on the sample which would degrade the DNA (Spear, 2004). When blood is in liquid form and is stored in glass vials the best storage is in a refrigerated unit. Glass vials tend to break when stored in a freezer so it is best to avoid freezing these samples. The only time blood should be frozen is if it is on a rough surface like cloth or carpet and needs to be stored on the sample without extraction for an extended time.

## **2.4 Chapter-2 Conclusion**

The application of DNA fingerprinting to crime solving is both delicate and extremely useful in the United States. By following the recommended procedures on a crime scene, law

enforcement agents and forensic scientists can prevent contamination of DNA evidence, properly remove evidence from the crime scene, and identify the victim and the offender by applying the use of DNA technologies, the apprehension of the correct criminals has become a much quicker and easier process. Investigators must be slow, careful, and methodical at all times during the entire procedure. Thankfully, modern society has accepted the fact that with the exception of identical twins, no two people have the same DNA sequence, otherwise investigators would wrongly accuse a person for a crime they did not commit, or simply have to leave many cases unsolved. This is a world that any normal human being would not want to live in.



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## Chapter 3: Landmark DNA Court Cases

The acceptance of DNA evidence in U.S. courts has not been a straightforward process. Accepting complex technical evidence not easily understood by jurors is based on a series of landmark cases that set precedence for what type of evidence is acceptable. The purpose of this chapter is to help document the effects of DNA testing on society by discussing some key landmark cases that paved the way for our current use of DNA testing. DNA fingerprinting is now used in all 50 states in criminal proceedings (Genelex, 2006; DNA 2003; 2008), but it has taken much judicial precedent to show the admissibility of DNA fingerprinting, to prove that the science, and show the techniques are reliable and *valid*.

### Admissibility of Scientific Evidence

Historically, the admissibility of novel scientific evidence has depended on a ruling from the Court of Appeals of the District of Columbia from the case *Frye v. United States* (DNA Evidence, 1998.) From this case, the “Frye test,” or “Frye standard” was established.

#### *Frye v. U.S., 1923*

The only criterion for the Frye standard is “general acceptance” by the “relevant scientific community” (*Frye v. United States*, 1923). The case involved James Alphonzo Frye, who was convicted of murder in the second degree. He appealed his case on the basis that he should be allowed to use a crude precursor (Owl) to the polygraph or “lie-detector” test, a method of measuring systolic blood pressure to determine relative anxiety. The result of the test, if allowed in the appeal, would be used by an expert defense witness who would testify in court. Josiah A. Van Orsdel wrote the courts now famous opinion:

“Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be *sufficiently established to have gained general acceptance in the particular field in which it belongs*” (Frye v. United States, 1923). (Emphasis added.)

The systolic blood pressure deception test was deemed to not have gained general acceptance in its field, and so the expert opinion based upon that technique was not admissible, and the guilty judgment made in the lower court was affirmed (Frye v United States, 1923).

States are free to adopt their own standards for the admission of evidence (Gilstrap, 2005), and “by the 1970s, forty-five states had adopted this common-law standard for the admission of novel scientific evidence” (DNA Evidence, 1998). The issue with the Frye standard was that there was no specification as to what “general acceptance” meant, or what the “relevant scientific field” was (Patton, 1990). The issues that needed to be addressed were “What shall be accepted? If accepted, then for what purpose? Who shall accept it? How many experts constitute general acceptance and in what field should they specialize?” (*Id.*) as Giannelli said, “[p]erhaps the most important flaw in the Frye test is that by focusing attention on the general acceptance issue, the test obscures critical problems in the use of a particular technique” (Scientific Evidence, 2008).

### *Federal Rules of Evidence, 1975*

In an attempt to make the criteria for admissibility less stringent, in 1975 Congress enacted the Federal Rules of Evidence (Patton, 1990). In 1975 (Ariens, 2008) the Federal Rules of Evidence became federal law, the rules were “constructed to secure fairness in administration, elimination of unjustifiable expense and delay, and promotion of growth and development of the law of evidence to the end that the truth may be ascertained and proceedings justly determined”

(Federal Rules of Evidence, 1975). The rules set a definition of relevant evidence (Federal Rules of Evidence, Rule 401, 1975): “[to] make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence,” and added very broad definition of admissibility: “all relevant evidence is admissible” (Federal Rules of Evidence, Rule 402, 1975). The Rules also suggested a balancing factor between its ability to prove a fact, and the dangers of confusing the jury (Federal Rules of Evidence, Rule 403, 1975) and set guidelines for scientific expert testimony: that the testimony must be “helpful” (United States v. Downing, 1985) and “(1) based upon sufficient facts or data, (2) the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case” (Federal Rules of Evidence, Rule 702, 1975).

This new enactment created ambiguity in how the disparities between the Frye standard and the Federal Rules of Evidence were to be interpreted, especially Rule 702, since “reliable” does not necessarily mean that it is generally accepted. The Federal Rules of Evidence were far more lenient than the Frye standard, which required first identifying what field the evidence fell under, and then determining if it was generally accepted. The Rules, however, relied on proving that the probative value of the relevant, reliable expert testimony out-weighed the risk of confusing the jury.

#### *U.S. v. Downing, 1895*

In ***United States v. Downing***, the appellant was indicted for mail fraud, wire fraud and transportation of stolen property (United States v. Downing, 1985). The co-defendants and the appellant claimed they were innocent dupes of a Reverend Claymore, but Claymore was identified as Downing by 12 eyewitnesses who he has done business with under the name

Claymore (*Id.*). The defendant Downing wanted to use an expert witness who would testify about the unreliability of the eyewitness testimony, which he was not allowed to do. The United States Court of Appeals, Third Circuit concluded that such expert testimony could, in theory, be helpful, and that the way to determine its helpfulness was to have an “on-the-record detailed proffer to the court, including an explanation of precisely how the expert’s testimony is relevant” (*Id.*).

This on-the-record explanation would take place in a pretrial hearing, called an *in limine* hearing (*Id.*). An *in limine* hearing “refer[s] to a motion before a trial begins” (The Free Dictionary, 2005). The judge ruled that it was impossible to tell if the testimony would have satisfied the Rule 702 of the Federal Rules of Evidence without such a hearing (United States v. Downing, 1985). Such an *in limine* hearing for the admission of novel scientific evidence would have to focus on “(1) the soundness and reliability of the process or technique used in generating the evidence, (2) the possibility that admitting the evidence would overwhelm, confuse, or mislead the jury, and (3) the proffered connection between the scientific research or test result to be presented, and particular disputed factual issues in the case (*Id.*).” Judge Becker, who wrote for the court, said that the Frye standard “is inconsistent with the policies animating the Federal Rules of Evidence,” and that the “mere relevance of novel scientific evidence does not hinge on its ‘general acceptance’ in the scientific community, Rules 401 and 402, taken together, arguably create an admissibility of novel scientific evidence,” and that a “reliability assessment does not require, although it does permit, explicit identification of a relevant scientific community and an express determination of a particular degree of acceptance within that community (*Id.*).” Becker went on to point out that the “non-judicial uses to which the scientific technique are put, may also constitute circumstantial evidence of the reliability of the technique,” and that a lacking of

non-judicial uses for a scientific technique could be taken as evidence of its lack of reliability (Mahle, 1999).

*Daubert v. Merrell Dow Pharmaceuticals, Inc., 1993*

The Frye standard was not explicitly overturned until 1993, in *Daubert v. Merrell Dow Pharmaceuticals, Inc.* (Daubert v. Merrell Dow, 1993). Daubert was a civil case where two children had birth defects, which their parents alleged was due to the mothers' ingestion of Bendectin, a prescription anti-nausea drug marketed by Merrell Dow Pharmaceuticals, Inc. Dow had an expert witness in epidemiology that had reviewed literature on Bendectin, "more than 30 published studies involving over 130,000 patients" (Daubert v. Merrell Dow, 1993). None of these studies had found the drug to cause human birth defects. However, Daubert had eight experts who said that Bendectin could cause birth defects, whose conclusions were based on test tube and live animal studies of Bendectin, studies of drugs with similar chemical structures known to cause birth defects, and the reanalysis of previously published human epidemiological studies (*Id.*).

The Supreme Court held that the data plaintiff Daubert presented was "inadmissible because they had not been published or subjected to peer review" (*Id.*). This was based on the Frye test, but, the petitioners "contended that the Frye test was superseded by the adoption of the Federal Rules of Evidence, since nothing in Rule 702 mentions anything about acceptance" (*Id.*). The court overturned "the austere standard" of the Frye test saying that it had been replaced by Rule 702, and endowed trial judges with a "gate-keeping" (*Id.* at FN7) responsibility, "to ensure that any and all scientific testimony or evidence admitted is not only relevant, but reliable." This became known as the *Daubert test* and set up a list of loose criteria by which a judge may decide

to admit or ban any evidence. These criteria were, (1) can the “theory or technique be tested,” and has it been tested? (2) Has the “theory of technique been subjected to peer review and publication?” (3) What is the “known or potential rate of error?” (4) What is “the existence and maintenance of standards controlling the techniques’ operation?” It was also stated that (5) “‘general acceptance’ can yet have a bearing on the inquiry”(*Id.*). The focus of this ruling was on reliability and relevance of evidence. The Supreme Court justices quoted Judge Weinstein in saying:

“Expert evidence can be both powerful and quite misleading because of the difficulty in evaluating it. Because of this risk, the judge in weighing possible prejudice against probative force under rule 403 of the present rules exercises more control over experts than over lay witnesses” (Daubert v. Merrell Dow, 1993).

The Supreme Court emphasized that these criteria were not meant to set a “definitive checklist or test,” and that “many factors will bear on the inquiry.” The hopes of these criteria, and provision of gate-keeping responsibility was to assure a fair trial, despite the fact that “Scientific conclusions are subject to perpetual revision. Law, on the other hand, must resolve disputes finally and quickly” (*Id.*).

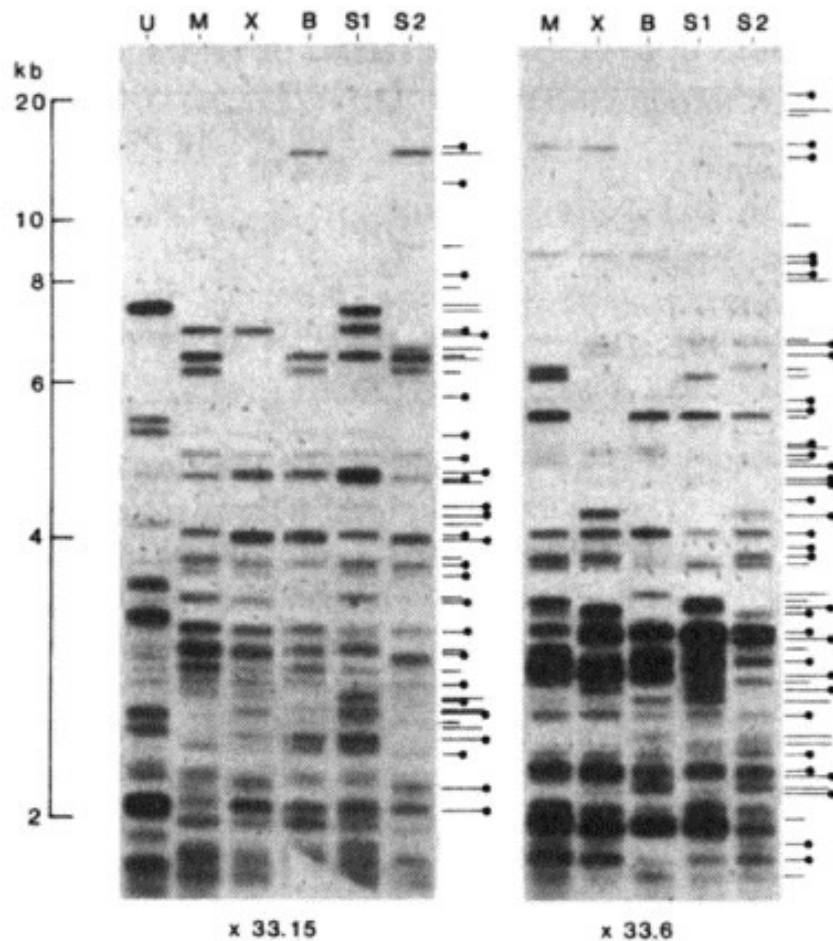
### **The Legal Role of DNA**

Now that the legal framework for the admissibility of novel scientific evidence has been established, a discussion of the legal history of DNA analysis’s admissibility in relation to the aforementioned cases will begin.

*Sarbah v. Home Office, 1985*

*Sarbah v. Home Office* was a 1985 immigration case in Britain (Aronson, 2005). Andrew Sarbah was a British citizen who had spent the last 11 years in Ghana, with his father, and was trying to get back into England. When he attempted to return, “immigration officials held him at Heathrow, saying his passport had been forged” (Millard, 1985). Sarbah’s lawyer was aware of a new DNA technique pioneered by Jeffreys, and contacted him to prove that Andrew is their son (*Id.*). This was the first case to incorporate DNA fingerprinting (Jeffreys, 1985c). In 1984, Sir Alec Jeffreys had unintentionally discovered DNA fingerprinting (Aronson, 2005), and published the discovery in *Nature* (Jeffreys, 1985a). Jeffreys could not get a DNA sample from Andrew’s father or aunts, (Jeffreys, 1985c) but got samples from the mother, brother and 2 sisters. Jeffreys “compar[ed] 61 bands and identif[ied] parental bands shared by his siblings.” (Aronson, 2005) (see Figure-3.1).





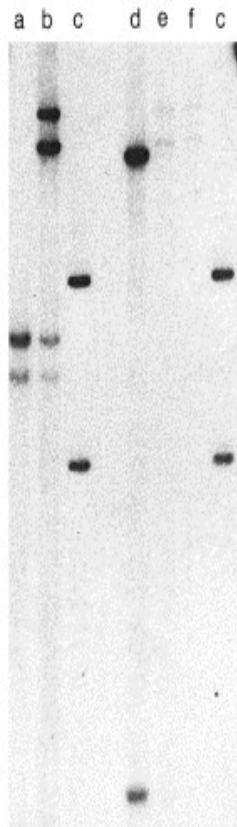
**Figure 3.1: Picture of the First Legal Application of DNA Fingerprinting in 1985.**

This data represents the RFLP-type analysis of a landmark paternity case. kb = kilo base-pairs. U is an unrelated individual, M is the mother, X is the boy in dispute, B is his brother, S1 and S2 are his 2 sisters. Each picture shows a different probe used. Fragments present in the mother are indicated by short horizontal lines to the right of each picture, while fragments not present in the mother, but in at least one of the siblings, are represented by long horizontal lines to the right of each picture. Maternal and paternal fragments transmitted to the boy in question are shown by a dot at the end of the horizontal lines. (Jeffreys, 1985c)

There are no bands present in the boy in question that are not also present in at least one of his siblings or his mother (Jeffreys,1985c), thus Jeffreys concluded that the probability of Andrew sharing the number of DNA fragments that he shared with his siblings and mother without being related was 1 in 33 billion (Jeffreys,1985c). The case was dropped by the Home Office, and the validity of DNA evidence was not discussed in this trial (Aronson, 2005).

### *Colin Pitchfork Case*

The next case, which showcased DNA fingerprinting, was also in Britain. Lynda Mann and Dawn Ashworth were raped and murdered by the same serial rapist, in 1983 and 1986, respectively, as evidenced by sharing similar *modus operandi* (Aronson, 2005). As Joseph Wambaugh said in his book *The Blooding*, which is based on these murder cases, “it [would] take four years, a scientific breakthrough, the largest manhunt in British crime annals, and the blooding of more than four thousand men before the real killer [wa]s found”(Wambaugh, 1989). A kitchen porter, Richard Buckland, had confessed to the murder of Ashworth (Aronson, 2005), but when Leicestershire police asked Jeffreys to compare a sample of his DNA to that of the Mann case, in the hope of linking the two, the suspect was not only shown to not have raped Mann, but also to not have raped Ashworth either, exonerating Buckland (Figure 3.2).



**Figure 3.2: DNA Fingerprinting Results of the Mann/Ashworth Case Exonerating Richard Buckland.** This data is from the world's first *murder* case involving DNA evidence. Column A is Lynda Mann's DNA. Column B is the vaginal profile from Lynda Mann. Column C is Richard Buckland's DNA. Column D is Dawn Ashworth's DNA. Columns E and F show the vaginal profile from Dawn Ashworth. The bands are faint, but it is clear that the rapist's DNA in columns B, E and F, are the same, and that they do not at all match those of column C, Richard Buckland's DNA (Aronson, 2005).

With their chief suspect eliminated, starting from scratch, a voluntary DNA dragnet was done by the police, where all men from ages 17-34 in the area where the crimes were committed were asked for blood and saliva samples. The dragnet ultimately collected 4582 samples (Aronson, 2005). The dragnet yielded no hits, until an informant overheard someone bragging about substituting his sample for someone else's (*Id.*). This person was questioned, and he quickly said that he gave a sample in place of Colin Pitchfork, who was then arrested and convicted of the murders of both girls, to which he confessed (*Id.*). This case also was not solved by DNA fingerprinting but by an informant, but Richard Buckland became the first suspect exonerated by DNA evidence (Skinner, 2008).

The first person to be convicted of a crime on the basis of DNA analysis was Robert Melias (Connors, 1996). Melias was convicted of rape in 1987 (Skinner, 2008). It was calculated that the chance of the sample from the crime scene not coming from him was 1 in 4 million of the male population (*Id.*). This evidence resulted in his conviction.

#### *Andrews v. State of Florida, 1988*

The first conviction using DNA evidence in the United States however, was the case of ***Tommy Lee Andrews v. State of Florida*** (Jasanoff, 2008). "Although investigators in mid-1987 had [already] used DNA fingerprinting to obtain a guilty plea against a rapist in Washington State, the Florida defendant in the *State v. Andrews* gained the dubious distinction of being the

first person maintaining his innocence to be convicted in the American courts on the basis of DNA fingerprinting evidence” (Blair, 1990). DNA from his blood was found to match the DNA from the semen in the rape victim, and the probability that the samples could belong to anyone else but Andrews was 1 in 839,914,540 (Derksen, 2000). The prosecutors for the case said that “they could find not indication ‘that anyone had ever done this before, but ... felt it was worth a try” (*Id.*). They sent samples to Lifecodes, a genetics company, from the rape scenes, and found matches between those samples and Tommy Lee Andrews (*Andrews v. State*, 1988). The opinion of the court cited *Downing v. United States* in saying:

“On the other hand, courts may look to a number of other factors which bear upon reliability. These include the novelty of the new technique, its relationship to more established modes of scientific analysis, the existence of specialized literature dealing with the technique, the qualifications and professional stature of expert witnesses, and the non-judicial uses to which the scientific techniques are put,” ultimately ruling DNA fingerprinting could be used (*Id.*). The court also based its decision on the fact that DNA analysis was a “well established procedure, performed in a number of laboratories around the world” (*Id.*).

*Spencer v. Commonwealth of Virginia, 1989*

In early 1989, the first death sentence based off of DNA fingerprinting was upheld by a State Supreme Court (Blair, 1990). *Spencer v. Commonwealth of Virginia* was not only important because it was the first case where capital punishment was based on DNA evidence, but it was the first case that a State supreme court affirmed (*Spencer v. Commonwealth*, 1989). “Some news accounts overstated the dramatic nature of the decision... (incorrectly describing Spencer as ‘[t]he nation’s first murder conviction based on the use of so-called DNA fingerprinting evidence’)” (Blair, 1990).

*People v. Castro, 1989*

***People v. Castro*** was the first case to challenge a DNA profile's admissibility (NCJRS, 2008). A woman and her daughter were murdered in 1987, the police questioned Jose Castro and found a bloodstain on his watch, which turned out to match the blood of the victims (*People v. Castro, 1989*). According to the allowance for pretrial hearings on the admissibility of scientific evidence made in *Downing*, a 12-week hearing (Patton, 1990) occurred in which both the defense and the prosecution brought in numerous expert witnesses. The court found that as general practice, "DNA forensic identification tests" (*People v. Castro, 1989*) were acceptable for inclusive and exclusive tests, and that the statistical criteria for exclusive tests was much more loose, but that in this case, the lab had not used the proper procedures, so the evidence was not accepted (Patton, 1990). The court set up a three-prong test for the admissibility of DNA fingerprinting:

**“Prong I:** Is there a theory which is generally accepted in the scientific community, which supports the conclusion that DNA forensic testing can produce reliable results?

**Prong II:** Are there techniques or experiments that currently exist that are capable of producing reliable results in DNA identification and which are generally accepted in the scientific community?

**Prong III:** Did the testing laboratory perform the accepted scientific techniques in analyzing the forensic samples in this particular case?” (*People v. Castro, 1989*)

The court found that prongs 1 and 2 and the generic statistical techniques were acceptable, that they had passed the Frye standard, but suggested that every future case employ a Prong III pre-trial hearing (*Id.*).

*U.S. v. Two Bulls, 1990*

In 1990 when Matthew Sylvester Two Bulls was charged with rape he appealed with the argument that the court should have used the Frye standard, being a more rigid standard, not the Federal Rules of Evidence in their decision to allow DNA analysis (**United States v. Two Bulls, 1990**). The court held that whether the Frye Test or the Federal Rules of Evidence were used, the Court needs to meet “all 3 tests laid out in Castro” (*Id.*). A 5-prong test was suggested by this case, which combined the features from Federal Rules of Evidence, Frye and the Castro tests:

“The trial court is to decide (1) whether DNA evidence is generally accepted by the scientific community, (2) whether the testing procedures used in this case are generally accepted as reliable if performed properly, (3) whether the test was performed properly in this case, (4) whether the evidence is more prejudicial than probative in this case, and (5) whether the statistics used to determine the probability of someone else having the same genetic characteristics is more probative than prejudicial under Rule 403” (*Id.*).

Prong 1 was adopted from the Frye standard (*Frye v. United States, 1923*). Prongs 2 and 3 were derived from prongs 2 and 3 of the Castro three-prong test (*People v. Castro, 1989*). Prongs 4 and 5 are elongations of Rule 403 from the Federal Rules of Evidence (*Federal Rules of Evidence, Rule 403, 1975*). Combined, the Castro and Two Bulls cases created a set of criteria to judge the reliability and relevancy of individual DNA analysis cases, which were not determined in either the Federal Rules of Evidence or the Frye standard.

*State of Minnesota v. Schwartz, 1989*

In 1989, in the case of **State of Minnesota v. Schwartz**, the court refused to admit DNA results from a private forensic laboratory (e.g. Lifecodes) stating that the lab did not comply with established rules and guidelines for analyzing evidence (*State of Minnesota v. Schwartz, 1989*). The Minnesota Supreme Court concluded that "...ideally, a defendant should be provided with

the actual DNA sample(s) in order to reproduce the results. As a practical matter, this may not be possible because forensic samples are often so small that the entire sample is used to testing. Consequently, access to the data, methodology, and actual results is crucial . . . for an independent expert review" (Connors, 1996). The "admissibility of [DNA] test results in a particular case hinges on the laboratory's compliance with appropriate standards and controls" (Cormier, 2005a).

A common in Schwartz, Two Bulls, and Castro was the reliability of the DNA testing in the particular case at hand. As a response to the questions of the reliability of testing methods, the FBI convened the Technical Working Group on DNA Analysis Methods, or TWGDAM, to establish procedures for testing DNA (TWGDAM Module 2, 2005). TWGDAM forensics experts worked with the National Institute of Standards and Technology (NIST) to develop a standard for the reliability of equipment and the DNA testing process (Cormier,2005b). The TWGDAM published a set of guidelines in 1991 (TWGDAM, 1991). The guidelines for the validation of DNA evidence said that the "validation process should include the following studies" (*Id.*): standard specimen, consistency, population studies, reproducibility, mixed specimen studies, environmental studies, matrix studies, nonprobative evidence, non human studies, minimum sample, on-site evaluation, and that all results of such studies be published as quickly as possible, so as to be peer reviewed (*Id.*). "Prior to implementing a new DNA analysis procedure...the forensic laboratory must first demonstrate the reliability of the procedure in-house. This internal validation must include the following:" testing using known samples, testing any modifications made on known procedures with known samples, to validate this new procedure with the same results, precision of matching process must be assured, no

contamination can be introduced by the procedures used, and the method must be tested using proficiency test samples (TWGDAM, 1991).

The TWGDAM group is now known as the SWGDAM, the Scientific Working Group on DNA Analysis Methods (TWGDAM Module 2, 2005). Along with the SWGDAM, the DNA Advisory Board (DAB) also provides forensics labs with operational standards, these standards are required for labs to pass “semiannual proficiency tests” by the FBI, passing these tests allows participation in national DNA database program, and also for laboratory accreditation (Cormier,2005b). These guidelines have no formal legal authority, but for labs to submit their DNA analysis to courts, they must show that they have passed the criteria for validation set out by SWGDAM. The DNA Identification Act of 1994 further validated these guidelines by stating that the guidelines set out by TWGDAM would be deemed “national standards” (Cormier,2005b).

*U.S. v. Jakobetz, 1992*

***United States v Jakobetz*** was the first major federal court decision to admit DNA evidence(DNA Evidence, 1998.). Randolph B. Jakobetz appealed his guilty sentencing to the United States Court of Appeals for the Second Circuit (United States v. Jakobetz, 1992). He was convicted of raping and kidnapping in Vermont, and he challenged the verdict of the court on several aspects of his sentence (*Id.*). The main claim being that DNA evidence should not have been submitted to the jury. The Second Circuit held the lower courts ruling, that the DNA should be submitted to the jury (*Id.*). The lower court had conducted pretrial hearing on the admissibility of the DNA evidence, as allowed in *United States v. Downing* (United States v. Downing, 1985). These hearings took 8 days and heard the testimony of 9 experts, 5 for the



government, and 4 for the defense (State of Vermont v. Jakobetz, 1990).

The Second Circuit determined that the ruling stood, since the judge from the lower court had gone above and beyond considering the 5 Williams factors (United States v. Jakobetz, 1992). The Williams factors hark back to the case of *United States v. Williams*, which was a narcotics case where a new kind of evidence, spectrographic voice evidence, was introduced and upheld. The judge cited several “factors” that should be looked at before admitting novel evidence, and agreed that the lower court had done so (United States v. Williams, 1978). These factors are:

“(1) The rate of error; (2) the existence and maintenance of standards; (3) the care and concern with which the scientific technique has been employed, and whether it lends itself to abuse; (4) its analogous relationship with other types of scientific techniques, and their results routinely admitted into evidence; (5) the presence of “failsafe” characteristics, which are “more likely to redound to his benefit than to his detriment” (*Id.*).

The judge from the Jakobetz case (State of Vermont v. Jakobetz, 1990) looked at many factors in addition to the Williams factors, the additional factors were:

“(1) The experts' qualifications and stature; (2) the existence of specialized literature; (3) the novelty of the technique and its relationship to more established areas of scientific analysis; (4) whether the technique has been generally accepted by experts in the field; (5) the nature and breadth of the inference adduced; (6) the clarity with which the technique may be explained; (7) the extent to which basic data may be verified by court and jury; (8) the availability of other experts to evaluate the technique; and (9) the probative significance of the evidence” (United States v. Jakobetz, 1992).

The judge in the Jakobetz case quoted the judge from *United States v. Williams* in saying that “[t]he essential question is not whether the technique is infallible, but rather whether the scientific technique exhibits 'a level of reliability sufficient to warrant its use in the courtroom' ” (United States v. Williams, 1978). The Second Circuit stated that, by considering these many factors, DNA analysis in this case satisfied the Williams standard, the Frye standard, and the Two Bulls and Castro standards, and that “such extensive hearings and findings should [not] be conducted in every case” (United States v. Jakobetz, 1992). They ruled that DNA analysis was

admissible, and that the protocol followed in a specific case would go to the weight of the evidence, that such evidence should go to the jury, and they can make the decision as to if it is reliable (*Id.*).

*U.S. v. Trala, 2003*

With the turn of the century, the prevalence of the more rapid PCR and STR DNA analysis became greater than that of RLFP and VNTR DNA analysis, and a new string of appeals questioning that technology upsurge (Cormier, 2005a). The courts held that both the process of PCR and using STRs over VNTRs and RLFPs was reliable and relevant, and hence, admissible in court (*United States v. Trala, 2003*). Different state courts consistently ruled that the PCR process was admissible (*United States v. Trala, 2003*; *State of Iowa v. Belken, 2001*; *The People of Colorado v. Shreck, 2004*). In *United States v. Trala*, the United States Court of Appeals for the Third Circuit ruled that during the pretrial hearing Trala had called, to challenge the admissibility of the DNA evidence, the district court had issued a “well-reasoned and comprehensive opinion” explaining why they had found the PCR/STR typing was admissible (*United States v. Trala, 2003*). They found that PCR/STR typing as applied to mixed DNA samples “did satisfy the standard for scientific reliability under Federal Rule of Evidence 702 or *Daubert v. Merrell Dow Pharmaceuticals, Inc.*“ (*Id.*).

*People v. Robinson, 2007*

Paul Eugene Robinson raped a woman in 1994 (Delsohn, 2001), but the police had no suspects. In August of 2000, with the six year statute of limitations for sex crimes about to expire, a John Doe warrant was released for an unknown male with specified tandem repeats

from the rape kit taken from the victim in 1994 shortly after the rape (*Id.*). DNA databases exist that are shared interstate (DNA Identification, 1999), and approximately 3 weeks after the warrant was issued, Paul Eugene Robinson was arrested (**People v. Paul Eugene Robinson, 2007**). This was the first case where a warrant was issued based solely on DNA evidence, and Robinson was convicted by that evidence. In his appeal, Robinson questioned the constitutionality of a warrant that did not name or describe him, to which the court responded that “applying these principles, we find an arrest warrant, which describes the person to be arrested by his or her DNA profile, more than satisfies the reasonable certainty standard because DNA is the most accurate and reliable means of identifying an individual presently available to law enforcement” (*Id.*). The court ruled that a warrant based on a DNA profile was acceptable, and in fact more reliable than a warrant based on descriptive or a name.

### **Chapter-3 Conclusion**

By 1996, forty six states had admitted DNA evidence into criminal proceedings (Connors, 1996). Today, all states allow DNA evidence in criminal proceedings (Genelex, 2006; DNA 2003; 2008). DNA fingerprinting has crossed the “twilight zone” between the experimental and demonstrable stages, originally elegantly mentioned in the Frye case, and is now a commonly practiced technique in forensic investigations. The techniques used, both for RLFP and VNTRs, and for PCR and STRs have repeatedly been challenged, but the irrefutable authority of DNA testing science has withstood such barrages, and expert witnesses have defended them passionately, frequently, and on so many levels, that they have been proven admissible under the Frye standard, the Federal Rules of Evidence, the Castro test, the Two Bulls test, the Williams factors, and the Daubert standard. DNA fingerprinting is now so trusted by forensic specialists

that cold-hit cases, like that of Paul Eugene Robinson, are accepted by courts, and the United States Legislature has passed bills recommending the re-testing of DNA evidence for death row inmates to exonerate any of the innocent.

“The state of the profiling technology and the methods for estimating frequencies and related statistics have progressed to the point where the admissibility of properly collected and analyzed DNA data should not be in doubt” (Connors, 1996). DNA analysis has and is impacting our legal system in a positive manner, and as the presiding judge from the case of *People v. Wesley* said almost 20 years ago, “[DNA fingerprinting] is the single greatest advance in the ‘search for truth,’ and [toward] the goal of convicting the guilty and acquitting the innocent, since the advent of cross-examination” (Blair, 1990).

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## Chapter 4: DNA Database Ethics

### 4.1 Introduction

The ethics of genetic technology is bewilderingly complex and controversial. It is not difficult to see why, as genetics occurs at the “normative and scientific” (Williams, p.546) nexus of so many aspects of humanity: being a technology, or rather a group of them, that provides an unprecedented level of awareness of ourselves at the molecular level. Similarly it affords us the tools to analyze our own nature, the composition of our societies, and even trace the path of our origins. In short, Genetics shines light on the nature of our *nature*. As a science, genetics represents a fundamental shift in our perception of biology and has begun to spill out into social and political phenomena. Collins declares:

*“the genomic era is now a reality...and a revolution in biological research has begun...[Genomics] has introduced an important new dimension into biological and biomedical research. Interwoven advances...will allow the functioning of organisms in health and disease to be analyzed and comprehended at an unprecedented level of molecular detail.”* (Collins 2, p.835)

Genetics itself is informed by and informs so much of the technology and knowledge we have painstakingly accumulated over centuries of civilization. The Human Genome Project, undertaken to sequence the entirety of the human genome (a staggering feat in and of itself, considering its three-billion-base-pair length), underscores this. It brought to bear the full force of physics, chemistry, and biology to accumulate the data—and required cutting-edge computer science and mathematics (in the case of shotgun gene sequencing and statistical analysis) to unravel it. From the Human Genome Project, entire schools of thought sprung<sup>1</sup>, along with many new technologies<sup>2</sup>.

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<sup>1</sup> For instance, The Human Genome Diversity Project and the science of pharmacogenomics and so-called psychiatric genetics (Cowan, p.3).

<sup>2</sup> Such as individualized preventative medicine and the predicted “designer drugs” (Collins, p.4)

While genetics has presented many ethical dilemmas, they all spring from a common root. As Thomas et al. puts it, “our ability to develop technologies and design new genetic tools far outpaces our evaluation of the efficacy and effectiveness of the tools” (Thomas et al., p.2141). Cho et al. agrees, commenting that “too often, the mere availability of data and technology, rather than ethical considerations or social needs, drives its use in unintended ways; therefore, the awareness and involvement of scientists in thinking about downstream uses is needed at the earliest stages of research” (Cho et al. p.S8). As evidenced by Thomas and Cho, technology and science have the tendency to march on, regardless of the ethical and cultural implications of their respective developments. This is exactly what is being seen in modern genetic technology; a body of knowledge that allows for a degree of comprehension and control over living things that far outstrips our conceptions of what the ethics of controlling living things are.

The primary focus of this chapter will be the ethics implicated in the implementation of DNA fingerprinting (DNAF) and, more specifically, the purpose and ethics of constructing DNA databases (DNAD) of any size—particularly for forensic and legal use. Even this comparatively small corner of genetic technology is fraught with ethical debate and discussion, due particularly to nature of a state-created DNAD for law enforcement purposes; these debates include the extent to which perpetrators of crimes can be considered to have waived their right to consent to DNAD inclusion, the length of time that samples or data are stored in a DNAD, the irrevocability of consent, its usage in identifying new suspects based on the data already stored within it, and the effects on privacy such a DNAD will have on the public at large. It also has a range of possible future uses that are both frightening and overwhelming—with many possible futures,

once the realm of science fiction, abruptly becoming possibility. As Lord Justice Stephen Sedley famously remarked, it is a “Pandora’s Box.”

In as much as they are case studies, discourse here will be restricted to the DNAD implements used by the United States and the United Kingdom. This is justified due to the similarity of the procedures used by both, in that they have nearly identical aims and extremely congruent legality associated with them. Also, the consideration that DNA is the substratum on which both databases act, and since the nature of DNA is equivalent regardless of the location of the database or the frames through which it is examined, the author feels it is both necessary and permissible to discuss both US and UK database models.

## **4.2 An Overview of DNA Databases**

### *4.2.1 DNA Database Basics*

The word database describes any collection of data stored for a specific purpose and arranged in such a way that it can be easily accessed, searched, and analyzed. A DNA database is therefore a collection of data obtained from DNA, be it the sequence of the DNA itself or a standardized representation describing a particular sample of the DNA (such as a DNAF). It is also possible to construct a DNAD from a collection of biological samples, where the entire genome is present but unsequenced: the useful data is obtained from the DNA after the fact should the need arise (*see* Fig.4.1). These two types of DNA databases carry different ethical dilemmas and will both be discussed.

A concise approach to the creation and nature of the usage of a DNAD, as opposed to simply what a DNAD is, is established by Williams:

*“[the] ability to construct digital representations of [DNA] profiles and store them in continuously searchable computerised (sic) databases has made possible*

*a vastly expanded role for DNA profiling in many criminal investigations. [DNADs are] increasingly applied inceptively rather than reactively...[DNA databasing] shapes an inquiry by identifying potential suspects from the start rather than merely supporting their incrimination or exoneration after they have been nominated for attention by other more traditional – and often very protracted – forms of investigative practice” (Williams, p.546)*

Thus the nature of the DNAD paradigm becomes apparent. Such databases are not restricted to collections of DNADs, in fact fingerprint databases (even those searchable by computer) have existed for quite some time prior to the establishment of the US and UK DNAD. However, all databases of this type share a common feature: they are not used just as evidence after-the-fact, but rather in the identification of potential suspects *before the fact*. In this way, DNADs transform DNA as a forensic tool from a means of taking a crime and a suspect and determining whether a particular suspect was present at the crime scene, to a means of taking simply a crime scene and identifying potential suspects.

Created by the state, a DNADs in their current form exist to combat crime by allowing the perpetrator of a crime to be identified more concretely through the use of DNA, which is currently regarded as the definitive article of identification (Nuffield, p.41) or even a “gold standard” (Thompson). The mission statement of the United States FBI National Combined DNA Index System or CODIS, currently the world’s largest DNA database, aligns with this:

*“[The purpose of CODIS is] to foster the exchange and comparison of forensic DNA evidence from violent crime investigations.” (FBI 1)*

The United Kingdom equivalent of CODIS is the National DNA Database or NDNAD, and has an expressed purpose very similar to that of CODIS:

*“As well as identifying offenders, [NDNAD] can also eliminate innocent people from enquiries. [NDNAD] helps to focus the direction of major investigations, resulting in savings in police time and in building public confidence.” (NPIA)*

The Police and Criminal Evidence Act of 1984 (PACE) elucidates the (currently) legally permissible uses of DNAD in the UK, permitting DNAD to be employed in the *prevention*, *detection*, or *investigation* of a crime, in the *persecution* of a suspect, or the *identification* of a deceased person (PACE).

The sources of the data to be included in a DNA database fall broadly into three primary sources. The names of these classes of samples are taken from the Nuffield Council on Bioethics, but their meaning is broadly conserved between American and British legal systems. The first class of samples are derived from those arrested recordable offense or the suspicion of being involved in one (Nuffield, p.8) and are taken from the suspect without their consent. These are known as “criminal justice arrestee samples.” In order for a sample from the first class to be useful, there must be another sample against which to compare it to so as to allow for identification. These samples may come from those already stored in the DNAD, or they might come from the crime scene itself, being collected by a forensic investigator during the normal course of investigation. Samples derived from the crime scene are termed “crime scene samples.” Samples of the third class are obtained from volunteers, witnesses, and victims for the purposes of identifying the source of biological samples found at a crime scene. Because crimes can take place in areas heavily trafficked by persons other than the perpetrator or the victim, a forensic examination of the crime scene will yield multiple samples. Those who provide samples such that they can be matched with crime scene samples and consequently eliminated from the pool of suspicious crime scene samples constitute this category. Samples of this class are consequently known as “elimination samples.” By combining the individual samples from each of these classes into a large compendium of DNA data, a DNAD is formed.

## 4.2.2 Specific DNA Database Implementations

### *UK National DNA Database*

For six years, the UK DNAD, NDNAD, was the largest forensic DNA database in the world. NDNAD contained (as of March 2007) some four million samples taken from criminal justice arrestees<sup>3</sup> and 264,000 obtained from crime scenes, with 715,239 criminal justice arrestee samples and 68,774 crime scene samples collected in 2005 alone (Nuffield, p.9). Taken together, the NDNAD contains almost four percent of the UK population. However, it is important to remember that an estimated 13.7 percent of the NDNAD are replicates (Nuffield, p.9). These replicates occur when an individual is arrested more than once, and on at least one occasion given a false name when the sample was taken. Collectively, the NDNAD has been a significant asset in solving some 3,000 crimes, including “37 murders, 16 attempted murders, and 90 rapes” (NPIA). Of the 1.3 million persons arrested in the UK between 2004 and 2005, 34.6% or 450,000 had a biological sample taken (Nuffield, p.10). New legislation in the UK (*see* Criminal Justice Act of 2003) permits law enforcement to sample, if they choose, all arrestees. This is a phenomenally large number of samples: according to a 2003 Crime and Justice Survey, 24% of UK males and 7% of UK females will be arrested at some point in their lives (Budd, p.57). According to a census conducted in 2001 by the UK Office for National Statistics (ONS), 28,579,869 males and 30,209,325 females lived in the UK. Thus, a simple calculation reveals that given enough time, NDNAD could potentially contain nine million individual samples, meaning that over 15% of the *entire* population of the UK would be in the database, which would more than double the size of the NDNAD.

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<sup>3</sup> By contrast, the UK’s national fingerprint database holds some 6.5 million individual records (Nuffield p.xiii).

### *U.S. CODIS Database*

The US DNA database situation is considerably more complex owing to the existence of databases at the local, state, and national level, producing a number of separate DNA database hierarchies. The DNA Identification Act of 1994 created a unified framework for these databases, and produced CODIS, the Federal Bureau of Investigation Combined DNA Index System (DNA Act, sec. 210301). CODIS is composed of DNA data from 180 laboratories in all 50 states (FBI 1), the US Army Crime Lab, the FBI, as well as data from criminal investigations of Puerto Rico (Cho, p.S10). Therefore the commonly known NDIS, the National DNA Index System, is the highest level of CODIS (being national) but it is still simply a subset of CODIS and not a distinct entity. CODIS also recently became the largest database of its kind, exceeding UK's NDNAD by over a million samples. As of June 2008, CODIS contains 6,031,000 criminal samples (termed 'convicted offender profiles') and 225,400 crime scene samples (termed 'forensic profiles') (FBI 3). The combined efforts of all 50 states contributing to CODIS have aided in some 71,800 investigations by producing 71,500 matches (FBI 3). Massachusetts alone has 4 labs participating in the CODIS program, and has produced 59,824 criminal justice arrestee samples and 3,173 crime scene samples. Collectively, these have aided in 877 Massachusetts investigations (FBI 4). Although CODIS is larger than NDNAD in terms of sheer volume of samples stored, considering the 304,600,000 person population of the United States (Census), it contains a comparatively paltry 1.7 percent of the population (compared to 8% for NDNAD). If we consider the average percent of the population to be criminal as roughly equivalent in both the US and the UK, NDNAD is more "complete" than CODIS. Thanks to legislation in many states that greatly expand the list of qualifying offenses, this percentage is likely to grow quite rapidly. Simoncelli predicts six hundred thousand samples to be added to California's database

alone each year, beginning in 2009 when Proposition 69 will go into full effect (*see* 4.4.4.1). While this may appear to be a good thing, it does run the risk of creating an enormous backlog for DNA analysis labs, and also generating significantly more “cold hits” each time the database is searched, something that could, in fact, bog down the law enforcement system. Nuffield and Williams point out that comparatively few crime scenes are actually searched for DNA evidence, and many felonies that will be included in CODIS and NDNAD involve no DNA at all. For instance, the US makes 1.6 *million* arrests each year for property crimes (Simoncelli, p.5). Under new legislation, it would be permissible to take samples from such felons. Asserting that such samples would be useful is dubious, as there is little correlation between violent offenders (who commit the felonies where DNA is most often left behind) and offenders in general.

The actual structure of CODIS is simple, yet often misunderstood. The “index” part of the name is not a misnomer: to preserve privacy, CODIS contains only the DNA sample analysis or DNA fingerprint, as well as index values that correspond to crimes, arrests, etc. No names, no criminal history, and no other personal details are stored in the database. Rather, if Individual I inputs Sample I into the database, CODIS’ search algorithm automatically compares Sample I to all known DNAFs on the database. It then returns 3 matches. The matches are simply a variety of numbers or “indexes.” Individual I must go to *other* databases that can take those indexes and match them with names, or crimes, or addresses, etc. Thus the common conception of an image with name, phone number, address, and so on popping up on a computer screen once the sample is entered into the database is a gross misunderstanding.



## 4.3 Constructing an Ethical Analysis

### 4.3.1 Introduction

As stated in 4.1, genetic technology in any form carries a heavy ethical burden. DNAD carries with it unique implications for personal rights, as its represent a mechanism by which identity is stored in a centralized location. Beyond this, genetic identity is perhaps the closest it is currently possible to come to actual identity, as it is the most inalienable. During a senate deliberation on the Genetic Information Nondiscrimination Act, Senator Edward Kennedy underlines this concept, saying “it is difficult to imagine information more personal or more private than a person’s genetic makeup” (Kennedy). In other words, while fingerprints can be removed or even changed, it is impossible to change one’s genetic structure without undeniably changing oneself and therefore one’s identity. A DNAD therefore has enormous effects on the nature of personal privacy and personal rights in general.

As mentioned in 4.2.1, the bulk of DNAD ethical issues stems from science vastly outpacing ethical discourse. Krimsky remarks:

*“Developing technology, rather than constitutional analysis and informed public decisionmaking (sic), is driving the expansion of DNA databanks. Neglected to date has been a responsible national debate leading to an understanding of the issues”* (Krimsky, p.2)

Without this public discourse, much legislation (*see*: Section 4.4.4.1) has been passed that has expanded the usage of DNAD unbeknownst to the public. Because of this, ethical ambiguities have solidified into ethical issues.

Now that it has been established that DNAF/DNAD is indeed ethically volatile, it is necessary, if we are to suggest (as we must, living in a liberal society) that DNAF/DNAD has ethical grounding, to ameliorate this volatility. In this discussion, DNAF/DNAD ethical volatility will be mitigated through the construction of an ethical analysis of the problems and threats

created by the technology weighed against their promise in the aiding of criminal investigation and therefore having a positive effect overall.

#### **4.3.2 Refuting the Null Solution**

In constructing an ethical analysis, it is necessary to show that the subject of the analysis possesses merit significant enough to be considered at all. If not, the “null solution” holds, wherein the subject is simply regarded as being fundamentally unnecessary considering its ethical implications. For instance, take the example of murder. Although something of a crass example, it provides us with a useful template to construct our justification. An ethical analysis is not necessary for murder as a viable option to anyone as, under any reasonable set of humanitarian assumptions, murder cannot be considered remotely beneficial to society and thus it is not possible to mitigate the ethical problems associated with it. Thus the null solution holds: that is to say, under no grounds can murder be held as ethical and therefore cannot be ethically grounded, and should simply be ruled out as a possible course of action. The Nuffield Council on Bioethics refers to this as the “necessity test” (Nuffield, p.34). And remarks:

*“...[The] necessity test posits that if a particular objective can be achieved by more than one means, the least harmful of those means should be adopted, that is, one that causes the minimum harm to the individual or community.”*

DNAF/DNAD does appear to satisfy the necessity test, and therefore refutes the null solution of not using DNAF/DNAD at all. While claiming that a particular case could not be solved through *any other means* other than using DNA technology is difficult and to some degree subjective, it is possible to assert that DNAF/DNAD has led to a number of convictions in cases that have gone unsolved for many years. Such was the case of the so-called “Night Stalker” of Goldsboro, North Carolina, a serial killer and rapist whose case went unsolved for nearly 10 years until a DNAF, obtained from a vaginal swab of one victim, was entered into the North Carolina DNA

database where it matched the sample of a man arrested for firing into a domestic residence (Using DNA). DNAF/DNAD have also been cited as a means to greatly expedite the speed at which cases have been solved. This is evident in the logic of the Prüm Treaty, a document created as part of the Schengen III (a border policing cooperation agreement) in response to the Madrid Train Bombings. According to the Prüm treaty, eleven EU member states<sup>4</sup> are to share DNAD information amongst themselves, with the aim increasing the speed at which criminals are detected and crime is prevented (Prüm Convention, ch.2 article 2), however this conclusion has been contested (House of Lords). Numerous experts in the law enforcement and political fields have attested to a laundry list of purported benefits from a DNAD. Beyond such isolated examples such as the Prüm treaty, these benefits will form the base of the discussions establishment of the necessity of DNAD:

- Automated DNAF comparisons in a computerized database will greatly speed the rate at which offenders are identified.
- The innocent will be more rapidly and more confidently exonerated.
- The evidence generated will be more reliable.
- Because DNAD searches are computerized, they are extremely cost effective.
- Criminals will be deterred by the accuracy and speed of DNA evidence.
- Public confidence in the judicial system will be increased.

Therefore, for the purposes of this discussion, DNAF/DNAD is considered to have passed the necessity test, and therefore merits an ethical analysis.

#### **4.3.2 What is Needed in an Ethical Analysis**

Bioethics, as well as ethics in general, are regarded as being at least somewhat subjective (Hoffmaster, p.3, p.226-8). Therefore, it is necessary to set forth a series of assumptions that will

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<sup>4</sup> According to the Prüm treaty: the Kingdom of Belgium, the Federal Republic of Germany, the Kingdom of Spain, the French Republic, the Grand Duchy of Luxembourg, the Kingdom of the Netherlands, and the Republic of Austria.

form the “axioms” of the analysis. This discussion will employ assumptions from a number of sources. DNAF/DNAD is particularly complex because it affects not only the individual, but also the society, being an entity composed of individuals as the indivisible unit. It is from the interplay of the society and the individual that we derive such notions as ‘State’ and ‘Legality.’ Thus, DNAF/DNAD necessarily includes these as it employs or affects every one of the aforementioned entities. As such it is necessary to form our assumptions on multiple planes, involving the individual all the way to the governmental.

Assumptions pertaining to the individual are of primary importance in the DNAF/DNAD debate. They will form the means to frame and consider the problems presented by DNAF/DNAD, as DNAF/DNAD is a technology primarily intended to aid the State in maintaining order, and as it is regulated by the State, it is reasonable to assume any ethical problem arising from DNAF/DNAD will be primarily inflicted upon the individual and not the State. Perhaps the most well-known discourses on the origin of individual rights is contained in the Declaration of Independence, which famously states that “all men are created equal” and are endowed with inalienable rights, such as “Life, Liberty and the pursuit of Happiness” (Jefferson). Because the origin of these rights cannot be empirically defined except through making an assumption (in this case, life, liberty and happiness are necessitated by a deductive argument: the assumption is equal creation, and the conclusion is that all are entitled to rights if any of them are as they are equal), they are ethical assumptions. Bioethics discussions closely follow suit when discussing what assumptions are necessary. The Nuffield Council on Bioethics lists liberty, autonomy, privacy, and equality as the rights to which it is assumed every human is owed, and DNAF/DNAD must be judged based on their effect on those four items (Nuffield, p.27-32), and it is from these that the necessity for informed consent and proportionality is deduced. ASLME

instead focused on the rights to privacy, specifically the right to keep information about ones identity (termed ‘who am I?’) private, as well as the right to keep ones spatial anonymity (termed ‘where am I?’) private (ALSME, p.2). However, they emphasized the importance of “truly informed consent” as absolutely necessary, and thereby a right of the individual, if the use of DNA forensics is to be justified (ALSME, p.4). Others express reservations framed within variations of “...am I?” questions, albeit using different terminology. Nuffield terms these questions “spatial privacy” and “informational privacy” (Nuffield, p.28). “Informational Privacy” introduces the final “...am I” question, which this discussion shall refer to as “what am I?,” a question pertaining to information gleaned from genetic data used for purposes other than simple identification. Bieber, although largely supporting DNAD, expresses similar concerns as “locational privacy” (where am I?) and “genetic privacy” (who am I?) (Bieber, p.1316). The European Human Rights Act (EHRA) provides a more specific definition of what is owed to a human in terms of privacy, reading that “everyone has the right to respect for his private and family life, his home and his correspondence” (EHRA, Article 8(1)). Another important notion is also gleaned from EHRA; that rights such as autonomy and privacy are “qualified rights,” in the words of Williams “a right whose exercise has to be balanced against the rights of others or the interests of society in general” (Williams, p.548). These rights are inalienable also, in the sense that their exercise may be modulated by extenuating circumstances (such as the crime that DNADs exist to fight) but such modulation cannot be allowed to “impair the essence” (Williams, p.549) of the right, in other words, the right may not simply be dissolved entirely, rather these rights are only attenuated so as to maximize, or prevent the attenuation of, those same rights applied to *others* (this relates the concept of the innocent collective versus the offending

individual, *see* footnote 8). Thus it is permissible to deprive an individual of some degree of freedom if that individual is depriving *others* of freedom.

Chadwick and Berg argue for two distinct sets of assumptions as to what is necessary to justify forensic DNA use. These assumption sets involve either “solidarity,” a principle wherein the rights of the individual are superseded by the individual’s duty to make decisions that will benefit the community at large, and DNAF/DNAD would be judged based on their effects on this solidarity. The other is based on equity, and the degree of the effect on equity that the DNAF/DNAD implementation displays (Ruth). For instance, Chadwick et al., suggests that any application of DNAF/DNAD can be justified as long as it is applied with complete equity. They are sure to note that equity implies informed consent, however, as without this it is impossible to assure the public that the technology is being applied with equity at all.

This discussion will regard Autonomy and Equality as the primary rights entitled to the individual. Equality is relatively simple to conceptualize. It requires one assumption, that is, that any set of individual interests displayed by any number of individuals must be regarded as equivalently “good” or valuable unless there is justification under the law for not regarding them equivalently (Nuffield, p.30). It is necessary because of the assumption of the State, wherein it is the State’s purpose to protect and help all who live in it. Autonomy is, however, more difficult to categorize. To this end, this discussion will adopt a simple means to justify and define autonomy. Frankfurt writes that autonomy is desirable because it will promote happiness, in that it will permit “the satisfaction of certain desires...whereas its absence means their frustration” (Frankfurt, p.17). Christman further defines autonomy as a condition requiring “moral authenticity, self-legislation, distinct self-identity (individuality), and self control” (Christman, p.110). Still others assert it is the ability to make oneself distinct from others in accordance with

one's own desires. Christman separates autonomy into two useful designations: autonomy as a condition (i.e., humans are autonomous) and autonomy as a right (humans deserve to be as autonomous as possible). Thus, we arrive at our second assumption: the *right* to autonomy. Taking a DNA sample without consent doesn't necessarily hinder one's autonomy as a quality (as you still have the capacity to be autonomous), however it does impinge on one's *right* to control oneself. From autonomy and equality, the other rights spring: informed consent is needed to preserve self control, privacy is needed to preserve a distinct identity, and liberty is simply held to be autonomy within the context of citizenship.

Accordingly, both Nuffield and ASLME also make assumptions about the State, and by interacting these assumptions with those of the individual through DNAF/DNAD technology the ethical problems are first presented. ASLME presupposes the importance of the State in regulating the general happiness of the society, but cautions

*"...a balance must be struck between such individual interests and the collective security achieved through the use of DNA for criminal justice purposes."*

(ALSME, p.2)

Similarly, they concluded that actions must be taken to limit the use of "forensic DNA databanks" to only the criminal justice system as it was imperative that public trust in the system was preserved (ALSME, p.3).

Nuffield takes a more direct approach to the nature of the State, and in lieu of presupposing its role in society makes two primary assumptions to which it must conform if DNAF/DNAD is to be considered ethical. The first obliges the state to a certain position that is perhaps obvious:

*"The protection of the public from criminal activities is the primary obligation of the state. However, this obligation must be exercised with due respect for a number of fundamental ethical values and in the light of modern legislation on human rights."* (Nuffield, p.27)

This will be generalized for the purposes of this discussion to “the State exists for the good of the people.” A governing body having this characteristic is meant when “the State” is referred to.

The second does not necessarily apply to States in general, but is aimed directly at liberal States such as the United States and the United Kingdom:

*“There is a strong presumption in liberal democracies in favour of not restricting [liberty, autonomy, privacy, informed consent and equality], but the presumption can be overcome in appropriately circumscribed contexts for compelling reasons backed by appropriate empirical evidence.”* (Nuffield, p.27)

This discussion will apply these obligations to the State as an assumption of what the State must do. Thus we have constructed our assumptions of the rights of the individual and the obligations of the State, the two bodies involved directly in the implications of DNAF/DNAD. These assumptions will be used to generate the ethical problems presented by DNAF/DNAD.

In order to judge the problem, it is lastly necessary to determine the ethical lens through which the problem is examined. Nuffield concurs: “The method by which one seeks to resolve these conflicting interests depends on the philosophical approach” (Nuffield, p.32). The Nuffield council will again come in useful as they outline three interpretations: a Utilitarian approach, a Libertarian Approach (termed “rights-based” in the paper), and a Duty-Based approach (Nuffield, p.32). Utilitarian and Libertarian are both consequentialist, as noted in the text, in that they are only concerned with the consequences of actions. Utilitarian emphasizes judgment (for instance, of DNAD) on the basis of the greatest good, for the greatest number, in that it is willing to sacrifice the few for the many. Libertarianism is the opposite, and it considers the consequences of DNAF/DNAD to the rights of the individual as of primary importance. Finally, a duty-based approach is less founded in rigor, being non-consequentialist<sup>5</sup>, and more in rooted

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<sup>5</sup> Indeed, the term for the class of ethical theories a rights-based approach belongs to is “deontology,” where the Greek *deon-* means literally “of duty” being held distinct from consequentialism, derived from the Latin meaning “to follow.”



belief as it is a lens that possesses absolutes. For instance, “Genetic Exceptionalism,” wherein genes are held to be fundamentally different from other types of information and therefore cannot be considered along with them (Murray, p.60) is considered a non-consequentialist philosophy. There are more outlandish approaches involving such philosophies as communitarianism, which states that as a group a society should articulate what is right and good and what is not, therefore taking a pseudo-democratic approach to DNAF/DNAD (Etzioni, p.214). Gillon contests this as being ultimately a populist model, and instead suggests “four bioethics principles” that readily fall into the assumptions put forth by Nuffield and ASLME (Gillon, p.310). On the grounds of the rigorous capacity of Libertarianism and Utilitarianism, owing to the fact that they have concrete metrics to judge an item on, this discussion will primarily employ them. Brea in mind, however, that these viewpoints strongly contrast, and therefore they cannot be used to make decisions: rather, they are provided for the reader to decide which is more appropriate and examine a given ethical issue.

#### **4.4 Ethical Problems Associated With A DNA Database**

The discussion has now arrived at what will become the bulk of the discourse: specific ethical problems associated with DNADs. The ethical topics associated with DNADs are, as already stated, voluminous. Williams concisely and eloquently summarizes such concerns:

*“[Concerns regarding the DNAD] have focused on: the threat to bodily integrity of citizens who are subject to the forced and non-consensual sampling of their genetic material; the intrusion and denigration of privacy rights caused by the storage and use of tissue samples; the potential for the future misuse of such samples held in state and privately owned laboratories; the prospect of long term bio-surveillance occasioned by the storage of genetic information in police databases and biological samples in forensic laboratories; and the possibility for the deceptive use of DNA forensic evidence in police investigations and criminal prosecutions” (Williams, p.546)*

It is obvious that there are a great number of ethical concerns held by the populace with regards to DNAD. In an attempt to structure these concerns in a coherent manner, this discussion will divide the issues into “functional categories.” These functional categories are as follows:

1. **Obtaining** DNA data (section 4.4.1)
2. **Analyzing** DNA data (section 4.4.2)
3. **Storing** DNA data (section 4.4.3)

Additionally the discussion will briefly examine possible future concerns of DNA databases, specifically the so-called “mission creep” or “function creep.”

#### **4.4.1 Obtaining DNA Data**

Every database, regardless of its use, must be considered in light of its constituent data. In the case of a DNAD, the data is particularly volatile because it is derived from human beings and crime scenes. Thus an ethical analysis of DNAD technology begins here, at the point where the data is physically obtained in the form of a biological sample.

In general ethical issues surrounding obtaining data centers on the concept of informed consent. This is because the nature of informed consent is such that, upon being given informed consent, performing the action to which the subject consented is ethical simply *because* it was consented to<sup>6</sup>. Consequently, upon obtaining fully informed consent taking and storing DNA data is no longer unethical. This is, of course, contingent on the consent being fully informed as this is required to make the decision. Section 4.4.1.1 discusses this further. Additionally, more

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<sup>6</sup> It is interesting to note that the assumption of autonomy is critical to informed consent. It is through informed consent of an autonomous entity an action on that entity can be regarded as fully ethical. It is difficult to derive this directly from the concept of autonomy, and it is commonly regarded simply as a necessary property of autonomy if we are to actually regard autonomy as *being able to make oneself*. (Christman, p.112)

practical ethical issues with informed consent are discussed, such as what “informed” truly indicates and how to ensure the consenter is actually informed.

#### *4.4.1.1 From Whom Do We Need Consent?*

In the UK, consent is needed unless the subject is *arrested* for a *recordable offense* (Nuffield, p.10). This distinction can be difficult as UK law employs three types of offense: arrestable, recordable, and non-recordable. Complicating the situation is the fact that these three offenses are not technically three distinct bodies. An “arrestable offense” now includes *any* offense, and “recordable” and “non-recordable” are subsets of these. In other words, recordable and non-recordable together constitute the whole of arrestable offenses. Therefore it is possible to be arrested for an offense that is not recordable, such as disrupting traffic.

In general, being arrested for a recordable offense indicates that you were arrested because a constable decided there was reasonable grounds to believe that you were about to commit, already committed, or were in the process of committing an offense that carries with it the possibility of a custodial sentence, that is to say, a sentence in which a punishment is imposed (such as imprisonment).<sup>7</sup> A Police and Criminal Evidence Act (PACE) review board suggested eliminating the concept of a dividing offenses into recordable and non-recordable because of the shaky ethical grounds on which it now stood, owing to the fact that sampling persons based on whether the offense they *may* have committed was recordable or not implies that there are those who are innocent but still “less innocent” than others. This reform permits police to take biological samples from all offenders regardless of the nature of their offense.

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<sup>7</sup> However, there are now over fifty offenses that are considered recordable yet do not have the possibility of a custodial sentence. Since these qualify as “recordable,” it is permissible to take DNA samples from them without their consent. (Nuffield, p.xiv)

In the United States, the situation of consent is more complicated. Unlike the UK, the consent requirement is regulated at both the state and the national level. The offenses are loosely divided into felony convictions, misdemeanor convictions, and arrests. Few of these categories have the same condition for all 50 states, with the exception of sex offenders: those convicted of a sex offense (as of 2008) *must* submit a DNA sample in all 50 states (NCSL). These convictions and arrests are further subdivided into more specific areas. Thus the data are quite complex, but a summarization is possible. Table 4.1 attempts to summarize current data on a state-by-state basis.

	Offense Class	Offense Subclass	# of States
Table 4.1: Qualifications for the Waiving of the Consent Requirement, State Totals (as of 2007)	Felony Convictions	All Convicted Felons	46*
		Juvenile Adjudications	32
		Jail & Community Sentence	49
		Retroactive Jail & Prison	39
	Misdemeanor Convictions	Retroactive Probation	25
		Few Misdemeanor	34
		Many Misdemeanor	3
		All Misdemeanor	0
	Arrests	Murder	11
		Sex Offense	11
Burglary		9	
All Felony		4	

\*Note: This was updated to be recent as of 2008 (NCSL). Table 4.1 Source: (Offenses)

The legality of consent in Massachusetts alone is quite involved. The current law states that anyone convicted of an offense that carries a prison sentence, or any youth that is convicted of an offense that would carry a prison sentence if that youth were an adult must submit a sample to the Massachusetts DNA Database within one year of their incarceration (Mass Law, Sec.3) must be sampled. In July of 2004, this law was amended to include persons who are incarcerated less than one year, thereby making a submission required by law either within one year or before release. As for refusing to yield a sample, such an act carries a penalty of not more than six months in jail, or a fine of not more than \$1,000 or both (Mass Law, Sec.11).

The question of course is, is it ethical to take samples without consent even if the person is a criminal? Obviously, taking a sample without informed consent impinges on personal autonomy, being that you are forced to do something, and privacy, as information about you will be shared outside your control. This issue is comparatively easy to discuss (relative to other issues presented in this discussion). It is presupposed by the legal system that anyone who is convicted of a crime has necessarily committed a crime, and in doing so waives their right to informed consent<sup>8</sup>. Excluding of so-called “Genetic Exceptionalism,” any school of thought would be foolish to require informed consent for DNA sample submission from a convicted murder, especially considering said offender does not give consent to being jailed, fined, or otherwise punished—but was punished anyway. Therefore, obtaining the DNA sample is framed as a mechanism of punishment as incurred by the offense.

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<sup>8</sup> This is an ancient concept, and has been around since the Code of Hammurabi in ancient Babylon, taking the form of “an eye for an eye.” Its recent conception was derived from John Locke’s idea of the “social contract,” where rights are derived chiefly from proper behavior in the society. Violating this proper behavior thereby waives rights bestowed by the contract. Williams concurs, referring to “the long established process of retaining ‘personal’ and identifying information from those convicted of criminal offenses” (Williams, p.547). It is perhaps helpful to construct a distinction between the good of the “innocent collective” and the rights ascribed to one who is legitimately suspected of committing a crime, and therefore proportionality is applied and sacrificing the rights of the suspect is weighed against the good of the “innocent collective” (Williams, p.549).

The proverbial thorn in this particular issue's side is in taking DNA samples from *arrestees* without consent. At this point, twelve states<sup>9</sup> authorize police officials to take DNA samples from persons arrested (NCSL). It is imperative to note that “arrestees” does *not* denote people who have committed a crime. Rather, it indicates someone who is under arrest for *any* reason. Therefore, it is possible to have DNA uploaded into the DNA database without ever having committed any wrongdoing. In that case, the State is limiting the liberty and privacy of a citizen for a prospective reason—rather than a concrete one. Determining whether or not this is ethically justified is difficult considering the lack of information; however for the purposes of perspective it may be useful to consider that under a utilitarian framework it would be justified if the negative impact on the hypothetical innocent-but-arrested individual is outweighed by the benefit of having the DNA of other individuals sampled under the same law who are guilty-and-arrested—but statistics on this benefit, if any, is lacking. A libertarian would assert, however, that the protection of the innocent is the supreme responsibility of the state, and they may not under any circumstances be used simply as a means in of themselves to some external end if the persons rights are being impinged upon. The hypothetical individual might feel persecuted and violated, a feeling that might spread amongst others and inhibit the efforts of the State to provide an environment that promotes the well-being of its citizens—further denigrating the justification for arrestee sampling under both a utilitarian and libertarian framework. Nuffield agrees with this, warning that such laws could “undermine social cohesion” (Nuffield, p.91).

Additionally, the misuse of such laws must be considered. Under the legality of arrestee-sampling, it would be possible for police to arrest an individual on fabricated suspicions, in order to obtain a DNA sample so as to check it against the database, or a specific sample. Consider a

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<sup>9</sup> Alaska, Arizona, California, Kansas, Louisiana, Minnesota, New Mexico, North Dakota, South Dakota, Tennessee, Texas, and Virginia.

tangential suspect in a crime, whose possible criminal implication is insufficient to justify enforced submission of a sample and whom refuses to yield on voluntarily. Such an individual would be a prime candidate for such abuses. In light of its potential for abuse, as well as the considerable infringement on the human rights of the innocent such policies entail, it would be difficult to justify at present. However, with improved statistics on the efficacy of a system, and through the presumption of benevolence on the part of the state, it is permissible for such a policy to exist and be ethical.

#### *4.4.1.2 Other Issues in Obtaining Data*

The exact nature of informed consent is under considerable debate. The absence of coercion or threats is presupposed in the nature of ‘consent,’ although it is difficult to remove the pressure to consent entirely, as per the old adage “you have nothing to fear if you are innocent.” Therefore, an individual would feel pressured to consent so as to show that they indeed have nothing to fear and are therefore innocent. While this is indeed an ethical issue, it is consistent with other procedures in the criminal justice system, and therefore is not an ethical issue unique to DNAF/DNAD.

In comparison with other criminal justice procedures, DNAF/DNAD does differ strongly in the amount of technical knowledge required to effectively comprehend the technology. Traditional fingerprinting, by comparison, is fairly simple: the image of the individual’s finger is replicated by any number of means and then compared to the similarly replicated image of a fingerprint left at a crime scene to determine the degree to which they match. DNA, however, is a molecule stored in each cell and is commonly touted as the “blueprint of life.” Something that both carries a lofty title, yet is so far removed from everyday life will be simultaneously well

known and yet poorly understood by the general population, and such a situation is rightly considered dangerous. It is the tendency of a society to create numerous half-truths about things such as DNA, having notoriety along with scientific complexity<sup>10</sup>. The layperson may have trouble, for instance, reconciling the popular idea of DNA being the blueprint of life, yet the particular DNA being examined does not, in fact, reveal anything about the individual other than identity (from the testimony of Dr. James Crow, during the National Commission on the Future of DNA Evidence, Crow) There is also a persistent belief that DNA evidence is completely infallible, or that the evidence is totally objective. Neither are correct, yet both may affect a persons decision to consent to having a sample taken.

The most commonly suggested solution to this is an assumption of good faith in the system and a broad-based community education approach (Hoffmaster, Ruth, Etzioni), to ensure an equal level of education amongst individuals. This is perhaps the optimal solution since an individual case-by-case educational system for informed consent is logistically difficult and has the potential to be uneven.

#### **4.4.2 Analyzing the Data**

DNA data does not reveal itself, but rather the sample must be analyzed to obtain data from it, and that data in turn must be *mined*, or processed, into a readily useable form (see fig 4.1). Different techniques associated with this data analysis may yield information that would not be readily considered to be derived from DNA. Two of the most controversial use statistical inference premised on the frequency with which certain phenomena in DNA, or, more accurately, STRs occur. These controversial techniques are *familial searching* and *phenotypic*

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<sup>10</sup> Case in point: the myth that humans “only use 10% of their brains.” Flagrantly false, but persists due to the notoriety of the brain and the general obscurity of neuroscience—i.e., it *sounds* like something that might be true.



*inference*. Neither of these produce definitive results when applied to a DNAD, but they can (hypothetically) narrow searches and cut investigative time down significantly.

These techniques are controversial because of the possible implications they can have for the presumption of innocence as well as (in the case of phenotypic inference) racial profiling. Thus they are the primary focus of this section, with logistical issues such as the role of private companies considered last.

#### *4.4.2.1 DNA-Based Phenotype Prediction*

Many discussions on the ethics of genetics centers around largely futurist applications of the technology, and consequently many are not readily applicable to the modern day. However, there exists a technique of analyzing data statistically in a DNAD that can elucidate the ethnicity of the person who yielded the sample under consideration. As elaborated in earlier chapters, the specific DNAF technique most widely used (Cho et al. p.S9) analyzes fixed sets of structures in the genetic code known as short tandem repeats (or STRs). The specific location of their occurrence within the genome of which is termed a *locus*, plural *loci*. In the United States, 13 loci are used for DNAF, whereas in the UK, 10 are used. These loci were explicitly chosen because they do *not* reveal sensitive genetic information beyond the identity of the subject (from the testimony of Dr. James Crow, during the National Commission on the Future of DNA Evidence, Crow), akin to how a license plate identifies an automobile, but does not reveal much more information. Utilizing statistical inference it is possible, however, to make an educated guess as to the *ethnicity* of the person who left a sample at, for instance, a crime scene (Lowe, p.17), but not medical predispositions.

It is immediately obvious that this presents a significant and unique set of ethical problems. The rights of a human being that the discussion assumed earlier are implicated here: this technique of ethnic inference impinges on both autonomy and privacy. The use of this technique implies that innocents will be targeted simply for sharing the subjective trait of ethnicity with the ethnicity a perpetrator is *inferred* to have from their sample, rather than an individuality they have created. This is, in effect, genetic marginalization. Williams remarks that while these ethnic implications may “accord with the rhetorical endoxa of many detectives” (Williams, p.555), that does not mean they are ethical simply by function of holding true in the minds of law enforcement officials. Secondly, privacy is also implicated, as this technique would provide investigators with reason to invade or otherwise disrupt the lives of the potentially innocent; while it is true that the innocent are often disrupted by criminal investigations, in any other area of criminal investigations *statistical inference* is much too diaphanous to justify such disruptions. This is especially true since such inference points to ethnicities, which are groups of individuals, not a single individual. Thus, even before the investigation has begun, the law enforcement officials are aware that *all but one* of those who will be disrupted will be innocent. Perhaps the greatest ethical issue would be justifying the psychological toll this can take on a group or community of a common ethnicity, as they are all potentially implicated in a crime through this method of inference (Nelkin, p.693). Simply put, this technique implies ethically unsound invasion. It is the obligation of the state to provide its citizens with protection from crime and harm inflicted by other citizens, but to do so with just cause. Thus these two must be reconciled, so as to establish a footing on which this technique can be said to be ethical. Ethnic inference passes the necessity test immediately, as determining the ethnicity of a criminal would potentially increase the rate of detection of that criminal, thereby increasing the aggregate safety of the state at a faster rate than

was previously possible—the alternative would be a costly and lengthy DNA dragnet, where all (or randomly selected) persons in a location are sampled, and that method carries with its own set of ethical issues (Nelkin p.692).

It is not clear if it can be made to be ethical, or at least if the ethical costs can be offset by the potential benefit. Cho et al. points out several problems inherent in this type of inference: it presupposes that STR allele frequencies can be assigned to an individual as consistently as they can be assigned to an ethnic group<sup>11</sup>. It also neglects the subjectivity (categories and ethnic definitions vary even between the US and UK) and the fluidity (a study cited in Cho et al. finds that one-third of US citizens studied had changed their ethnicity even in the past two years) of ethnicity (Cho et al., p.S9). Because of the complex interaction of genes with each other, common problems of inference include the “correlation implying causation fallacy,” the presence of a “lurking variable,” and the illicitness inherent in the use of a representativeness heuristic such as this on a single individual (*see* footnote 11). Although eliminating these would be possible, the DNAD would have to be very large so as to rule out any unseen correlation not including ethnicity—the Nuffield Council points out that it might not be possible, due to insufficient variation between ethnicities, and that “in biological terms, humans are one undifferentiated species” (Nuffield, p.80). They also cite the “chain of inference” between the DNA fingerprint and ethnicity as being overly long and therefore prone to error, and finally note:

*“The different alleles of markers in the SGM+<sup>12</sup> [STR fingerprinting technique] appear with different frequencies in different ethnic groups, but the frequencies*

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<sup>11</sup> It is interesting to consider that it is a mathematical property of an average that, for any number of members in a set (such as a group of people belonging to a common ethnicity) having a common attribute or value (like skin color) , no member of the set necessarily has the attribute having a value equal to the average of the values. In other words, on a 24-hour road trip, a number of miles are driven every hour. The average miles driven per hour could be 60 without ever actually having gone 60 miles on any specific hour. Thus it is possible to have a DNAF corresponding to the average of an ethnic group without having *any member* of that ethnic group possess that DNAF.

<sup>12</sup> SGM+, or Second Generation Multiplex Plus, is the 10-loci DNAF system currently in use in the UK.

*are statistical properties of groups, not individuals. All alleles can be found in all groups.” (Nuffield, p.80)*

Therefore, because of the subjectiveness of the topic and the effect it would have on already-existing ethnic tensions, ethnic inference is not currently ethically permissible, due to the effect it could have on society at large as well as the possible detriment to innocent individuals. In spite of the grave ethical implications of DNAD ethnic inference, and its (as of now) limited efficacy, CODIS has begun analyzing DNA data for production of ethnic inference statistics. This was largely the result of a recommendation of the National Research Council Committee on DNA Forensic Science in their 1992 report *DNA Technology in Forensic Science*, where they state:

*“In summary, population differences must be assessed through direct studies of allele frequencies in ethnic groups. Relatively few such studies have been published so far, but some are under way. Clearly, additional such studies are desirable<sup>13</sup>” (NRCC, p.82)*

Currently, ethnicity inference through the use of DNAD data is also in use by the UK, on a much lower scale, with only 5 requests on record for ethnicity interpolation from a sample collected (Nuffield, p.81). However, a study is being undertaken by the British Forensic Science Service (FSS) to use the frequency of Y-chromosome (the male sex chromosome) haplotypes to predict ethnicity in males, due in part to the highly conserved marker combination present on the chromosome (Nuffield, p.81). This technique was first used in anthropology over a decade ago, and appears to produce results that are quite reliable (Kittles, p.1171). Even with complete reliability, the ethical issues of ethnic group stigmatization and racial profiling are preserved.

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<sup>13</sup> It is interesting to note that in the same report, the NRCC paradoxically expressed the desire to limit the scope of DNAD: “The committee recommends approaches for making sound estimates [on the chances of two samples matching] that are independent of the race or ethnic group of the subject.” (NRCC, p.9)

#### 4.4.2.2 *Familial Searching*

Another issue under considerable debate is the use of familial searching. Indeed, the topic of familial searching shattered what had been a general consensus on the permissibility of DNA evidence between the British agencies ACPO, The Home Office, the Information Commissioner, and the Human Genetics Commission (Williams, p.555). There are other names for it, such as “indirect genetic kinship analysis” (Bieber, p.1315) and “blood relative inference” (Simoncelli, p.288) but they all pertain to the same method. Like phenotype/ethnic prediction, familial searching relies heavily on statistical properties of the STRs obtained from a sample—wherein the concept that close genetic familial ties (a sibling or children, as distinct from familial ties produced by marriage) to an individual will have closely related DNA fingerprints is employed to interpolate the origin of a sample by searching a DNAD for close possible relatives (Bieber, p.1315). Once these individuals have been identified, samples from their relatives are in turn taken to search for the sample origin. The technique relies on a number of assumptions not readily apprehensible but present nevertheless: it assumes that criminality runs in families, that family members are necessarily located in the same geographic area, and that offenders commit crimes in a localized geographic area—it should be noted, however, that these assumptions are heavily supported by criminal statistics (*see* Harlow). Much information can be gleaned from inquiries of family members that is highly subjective but still used by law enforcement. Gans terms this “request surveillance,” wherein the anxiety level of an individual is measured when that individual is asked to provide a sample (or asked about the individual’s family so they might provide samples). This is of course premised once again on the notion that if one is innocent, one has nothing to fear, and therefore a fear reaction to such an inquiry could be taken by police as an indicator of guilt or at least a guilty conscience (Gans, p.171). Nuffield has a number of

examples as to how this technique is employed, which this discussion will summarize for the purpose of comprehension. For instance, consider an unknown perpetrator (Individual 1), who leaves a sample at a crime scene. Individual 1's sample is collected and analyzed. It is found that it does not match any sample in the database. However, another individual, Individual 2, has a sample quite similar. Individual 2 is asked to provide information about their children, and Individual 2's children are in turn tested and it is found that Individual 1 was indeed one of Individual 2's children.

In the preceding example, DNAD Familial Searching was used effectively. Despite its potential uses there are many questions remaining pertaining to the technique's impact on privacy. Unlike other ethical issues, this particular issue affects privacy nearly exclusively: consider the implication it may have when it reveals unknown familial relations, or demonstrates the illegitimacy of a familial relations. For instance, if Individual 2 is supposed to be a man, it is conceivable that one of his children could be illegitimate, a fact that DNAD Familial Searching would reveal. It is also possible that familial searching could reveal unknown relations, such as the true parents of an adopted child. Such situations are not always desirable, and the State is certainly not in a position to reveal them, especially if their connection to a criminal case is tangential. Finally, familial searching has the ability to reveal aspects of one's past that one does not want to reveal. Consider Individual 3, a new individual, who is apprehended in Britain for a crime s/he did not commit. As is the law there, s/he would be sampled and his/her DNA fingerprint recorded and placed in the NDNAD. Years later, his/her name comes up during a familial search. The police arrive at his/her house asking his/her family members to submit samples, and consequently reveal to his/her family that s/he was a suspect in a crime at some point in his/her life—a fact s/he very probably did not want them to be aware of, especially

considering Individual 3 was found to have no involvement in the crime. It is now easy to see how a simple database search could theoretically disrupt families and communities quite significantly.

Another ethical issue arises from the disproportionate representation of ethnic minorities in CODIS (Simoncelli). While a familial search could return a relative of the source of an unknown sample, it will also return many unrelated hits. Because a greater proportion of the DNAD is composed of ethnic minorities than in the actual population, it follows that a greater proportion of the hits will come from ethnic minorities. Thus, it is possible a white perpetrator can commit a crime that will lead to the investigation of primarily Hispanic or African groups. This has profound implications for race relations as well as the equity that is stressed by the legal system. It is possible that this will not be the case due to probabilistic segregation of samples along ethnic group delineations—the same phenomenon enabling ethnic prediction from DNA DNAs to take place. It is currently unclear as to whether or not this probabilistic segregation is overcome by random variation in alleles, thus it is possible that either case is true. Although anecdotal evidence currently weighs on the side of familial searching producing disproportionately ethnic results: studies indicate that genetic variation between two randomly chosen individuals is far more significant than genetic variation between ethnic groups (Nuffield), potentially indicating that ethnic alleles would have a small effect on familial search results.

These are significant impacts on certain presupposed rights. However, they might be mitigated by considering the potential benefits of familial searching along with the physical (non-ethical) problems associated with it. Bieber gives two cases in which familial searching was used effectively: Jeffery Gafoor and Willard Brown (Bieber, p.1315). Gafoor was implicated in

an extremely violent homicide, wherein a young woman from Cardiff, Wales, named Lynette White, was murdered at age 16 in 1988. The murder went unsolved for 15 years, until a rare allele was identified in a boy, age 14, in 2003. This allele matched one found in samples taken from White, and this led investigators to Gafoor. Brown was also guilty of brutally raping, sodomizing, and then stabbing to death a woman, aged 25, in August of 1985. Police questioned him after a near perfect match was found to derive from his brother. Brown subsequently confessed, leading to the acquittal of the man previously convicted of the crime, 19-year-old Darryl Hunt. Both Brown and Gafoor were convicted of murder. In the UK, at least 20 crimes have been solved using familial profiling since the inception of NDNAD (Williams).

Certain statistics also back up assertions that familiar searching is a valid method of apprehending criminals. A 1996 survey of prison inmates by the U.S. Bureau of Justice Statistics found that 68.4% of all inmates had at least one family member ever incarcerated (Harlow, p.69, Table 4.27). An article in the Harvard University Gazette cites similar figures (Cromie). The same article wrote of the dismissal of privacy concerns by various court cases, wherein the Judge claimed that the interest of public safety outweighed the violations of privacy. Two states—Massachusetts and New York—permit familial searching (Axelrad, p.2). Indeed, Massachusetts explicitly allows familial searching. This provision is set forth under Mass. Regs. Code 515 § 2.14: Mutual Exchange, Use and Storage of DNA Records, where the number of loci required to generate a match is permitted to vary based on, but not limited to “the apparent presence of mixtures, sample degradation, limited sample availability, or *the possible involvement of relatives.*”

However, such statistics can be misleading. A familial search of even a comparatively small database will yield an enormous number of results (Nuffield, p.79). This is due to the fact



that as the “allowable tolerance” of the percent match, that is, the percent deviation from the sample in question that is tolerable in order for a DNAD-derived DNAF to be acceptable, may be increased linearly but the number of matches will increase *exponentially*<sup>14</sup>. In other words, an investigator may find that under a certain allowable tolerance, no results are returned, but a small increase in the tolerance and a repeat search will yield hundreds of results.

Thus there is a significant obstacle in the number of hits that must be investigated to yield a result. Using a Monte Carlo method (a means of measuring statistical phenomena associated with random sets, such as the set of DNAF in a DNAD), Bieber finds that, given a DNAD of 50,000 individuals, even if a close relative of the origin of a given sample is in the database, using familial searching the relative would be identified 62% of the time from the first hit, but over 100 leads would have to be investigated before one can be 99% certain that the relative will be identified (Bieber, p.1316). While these statistics seem heartening, several items must be kept in mind, that exemplify the deceptive nature of such statistics:

- The simulation presupposes that the sample origin has a relative within the DNAD
- To be 99% sure of identifying the relative, over 100 leads would have to be investigated
- These statistics relate to the *relative* of the sample origin, not the sample origin itself
- CODIS contains over one hundred times the amount of individuals as in the simulation
- Leads could be generated even if the sample origin does not have relatives in the DNAD

With these considerations in mind, applying a familial search method to CODIS would be significantly less simple. Making the same assumptions but scaling the simulation up to CODIS levels (about 5,000,000 individuals), *nearly 10,000 leads must be investigated* in order to be 99% sure of locating the relative, *if and only if the relative is in the database*. For ever increasing

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<sup>14</sup> This is a property common to any system involving population statistics. It is the result of the nature of a confidence interval and the distribution of elements in the population. It is closely related to how, in a missing persons search, the search area increases exponentially while the search radius increases linearly.

percentages (i.e., approaching 100%) the number of leads investigated follows a logistic curve, first increasing exponentially and then, while still increasing, begins to increase at an ever slower rate.<sup>15</sup>

Thus while familial searching has had success and certain statistics appears to indicate that the technique carries significant merit in crime solving, the myriad of ethical issues presented by it as well as the logistic problems presented by the invariably high number of results generated significantly detract from its capacity to be justified. Our ethical lenses again reveal divergent opinions; because it has been shown to work in solving violent crime cases, Utilitarianism views it of great potential benefit to society, and with the exception of its possible effects on race relations, minimal impact on society at large. Thus, under a utilitarian framework such a technique would be readily adopted. This is nearly inverted for Libertarianism, viewing its impacts on privacy as significantly outweighing any potential impact it might have solving cases, especially as such cases, requiring perpetrators to have unique or rare alleles, are bound to be rare<sup>16</sup>.

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<sup>15</sup> The curve is logistic, i.e., the rate of increase decreases as the percentage desire increases because of the limit imposed by the physical number of samples in the database. At some %, such as 99.9999%, you will have to search all 50,000 leads. This number *cannot* increase because there simply are no more leads within the database.

<sup>16</sup> Certain techniques of DNA database searching, known as “multiple profile comparisons” actively compare each DNAF in a database to try to draw familial relations in the hopes of identifying a sample. Such searching are fraught with difficulty, because of the enormous numbers involved. In performing a comparison search, even a small number of total DNAFs results in a large number of comparisons being computed. This number can outgrow even the formidable capacities of a computer with surprising speed, especially considering the number of DNAFs that CODIS contains. Without delving too much into the mathematics of the situation, each comparison search creates what is known in mathematics as a “complete graph,” where every vertex (a DNAF) is connected (compared) to every other vertex. Thus for a database having  $n$  DNAFs, the number of comparisons that must be made is  $n(n - 1) / 2$ . A database of 10 DNAFs requires 45 comparisons to complete. A database the size of CODIS (~5,000,000) would require an astonishing 12,499,997,500,000 comparisons to complete. Thus, even without the ethics, such familial searching may grow to be computational infeasible as the number of comparisons is simply too great for current computing power. This phenomenally large number also generates a great number of matches, even if the 1:113000000000 match likelihood the FBI maintains (Felch, p.1), which may account for the seemingly impossible number of matches found by the FBI lab technician mentioned in section 4.5.

#### 4.4.2.3 Other Issues in Data Analysis: The Role of Private Companies & Human Error

A blend of private and public groups carry out DNA analysis in the United States, although there is a current trend toward the privatization of such analysis. The UK (Nuffield, p.91), along with many states in the US (Simoncelli, p.286), employ private companies to carry out DNA profiling from the samples collected by their law enforcement officials. This trend is growing: recently the UK shifted their entire governmental organization, the Forensic Science Service (FSS) to a profit-seeking company (Nuffield, p.91). Important questions remain unanswered, however. For instance, the reason DNAD were allowed to exist in the UK and the US is because privacy was assured. Now that the data is in the hands of private companies, it is difficult to make such assurances because of the lack of an oversight body. Many troubling incidents have emerged from this shift to private companies, which take the situation further into unethical waters. Not only private companies will be considered in this discussion; other problems have emerged in DNA analysis by public groups. In short, certain episodes in the analysis of DNA data by private companies and public groups have taken something that was *in principle* ethical, or at least taken to be ethical, and eroded the foundations that it was built upon; these principles under consideration, in this discussion, to be privacy and equity.

Equity may seem an outlandish choice as the grounds for an ethical issue such as this. However, it must be kept in mind that equity implies equal treatment for all, or at least *as equal as possible*. This includes persons in the criminal justice system. Thus, we are obliged to examine the regularity of DNA analysis as it follows that uneven, and thereby unequal, DNA profiling is certainly not equitable considering the gravity of the matter it's being used in (for instance, a murder trial). Obviously no analytical procedure, outside of mathematics, can be repeated twice and yield results that are exactly the same. However, as examples will show,

DNA analysis by both crime labs and private companies is sometimes vastly less than ‘equal as possible’ between samples.

The Houston Police Department Crime Lab (HPD CL)’s DNA division came under widespread fire in late 2002 after an official investigation showed enormous problems in the handling, analysis, and interpretation of data (McVicker). In January of 2003, the crime lab was shut down pending a large-scale investigation. The investigation took over two years to complete, and cost five-point-three million dollars (Khanna). Ultimately, 1300 cases were tagged as requiring ‘further investigation’ (Simoncelli, p.286). 274 cases showed biological matter that was detected *but never tested*. 139 cases where a blood type was obtained from a sample but was never compared to the suspect. 180 serology tests to be faulty, but most troubling, six cases where DNA was retested completely discredited the previous DNA analysis (Khanna). It should be noted that these data were used in convictions—currently, three men who were convicted of various violent crimes, Leroy Lewis, Ronald Cantrell, and Lawrence Napper are no longer linked to the biological evidence used to convict them (Khanna) and one man, Josiah Sutton, was released from prison after serving four years due to a conviction using faulty DNA evidence (Simoncelli, p.286). More crime labs are now under review, in Fort Worth, Oklahoma City, Baltimore and Phoenix (Simoncelli, p.286). Cases like these are taken (and this is emphasized repeatedly in sources from the government, newspapers and articles detailing the HPD CL case) as the exception rather than the rule. However, it is still troubling as it has implications for the true nature of the equity with which DNA is administered.

Private companies are far from free of gross technical error. In an extremely troubling case, an employee of a private DNA testing company was shown to discard equity all together. The case involve Sarah Blair, who has since been terminated, of Orchid Cellmark, the world’s

largest DNA testing firm, electronically manipulating the results of DNA analysis. The specific nature of her transgression involves some knowledge of scientific experimentations: if one is to determine the presence or nature of a particular item, such as DNA, within a sample it is necessary to perform the experiment with a negative control. The negative control is performed with everything exactly the same, except no sample is added to the negative control. Thus, if the negative control is negative (i.e., shows nothing) and the sample yields a signal of any kind, one may be reasonably sure that the signal is the result of the sample, as the negative control received everything the sample did and did not yield any signal.

Sarah Blair simply deleted the negative control from the electronic display of the results (Cadiz). In other words, when a negative result showed a signal, Blair would delete that signal in an effort to make it look like the signal from the experimental sample was valid and not the result of possible contamination. Blair is accused of repeating this on at least twenty tests (Simoncelli, p.286). This is unethical and troubling for obvious reasons. Although this is again an exception and not a rule, private companies (because they are working for a profit) tend to have greater performance expectations of their employees, and thus put greater pressure on the employees. How then is it possible to assert that DNA testing by private companies is equitable when employees are pressured to perform, to the point where they will willingly fabricate data to appear to satisfy expectations?

It's possible that both these issues can be rectified with increased oversight. However, this oversight is not yet in place and it is clear that current testing is not equitable, regardless of how rarely this inequity occurs.

Major privacy concerns have been provoked by the use of private companies to analyze data. The issue is not entirely attributable to private firms, however. For instance, in the UK

police provide private companies with ‘datacards’ containing the name and gender of the sample origin. Private companies have commented that this is not necessary and could potentially compromise the privacy implicit in such actions (Nuffield, p.xxi).

A 2006 investigation by the British newspaper The Observer, a Sunday-edition version of The Guardian, in cooperation with GeneWatch, a publication of the genetics watchdog group Council for Responsible Genetics, found extremely troubling practices within the company LGC which could seriously compromise privacy without any need for the government enabling them to. LGC, the largest privately owned forensics company in the UK (LGC), has been secretly retaining the DNAFs, personal details and samples of all individuals who have had samples sent there by the government (Barnett).

The firm admits to storing the sensitive items, stating “All information is in [our system]. We do in effect have a mini database” (Barnett). The company defended itself by remarking that this is a procedure required by the government, in the event that repeat testing becomes necessary. Additionally, before condemning LGC completely, it is important to note that The Guardian unearthed no evidence of LGC using the data for anything other than its intended purpose.

Human error plays a part in any endeavor, and alone cannot justify throwing out any technique because of the human error involved. Rather, it is possible to compensate by attaching less weight to DNA evidence. Persons should be educated as to the possible fallibility of humans employing the profiling technique, so that it is judged as an extremely accurate *yet still fallible* method of identification, rather than as foolproof gold standard<sup>17</sup> it is currently seen as (Lynch, p.93).

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<sup>17</sup> DNA evidence is repeatedly referred to as a “gold standard” among identification techniques and even as evidence for conviction, especially by groups in the media and even in academic journals (Omagh, Telsavaara, Mnookin),

The ethical implications of the involvement of private companies is more complex; private companies alleviate strain on crime labs to process extremely voluminous amounts of samples and supply the ability to check samples between two labs for accuracy. However, they are also not infallible, and as was demonstrated profit-driven interests may be construed as being at odds with the impartial equity presupposed in the legal system. An increase in oversight, for example a system where randomly chosen samples are sent to *two* private labs could check for accuracy and quality-assurance purposes<sup>18</sup>. To prevent ethical implications in quality-assurance, the samples could be taken from volunteers, anonymized, and destroyed thereafter.

#### *4.4.3 Storing the Data*

The ultimate purpose of a DNAD is, of course, to store data to provide a base for information so that it can be readily accessed, with data being easily arranged and examined. Storing the data is therefore an obvious ethical pitfall. These are pitfalls primarily because they don't *appear* to be terribly volatile initially, but upon examination they prove to be very controversial. These take the form of initially-subtle distinctions: storing the data for a finite vs. an indefinite (i.e., up to the discretion of the State) period of time, and storing samples versus digitized data. Therefore this discussion will center around those issues entirely.

##### *4.4.3.1 Storage Time*

DNAD data storage time is a relatively simple concept, denoting the period of time that a sample is retained on the part of law enforcement. However, there exists an enormous gap

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however recently there has been a growing number of publications advocating skepticism towards DNA evidence (Thompson, Felch).

<sup>18</sup> SWGDAM, mentioned earlier in this paper, already imposes a similar system wherein crime labs are expected to reproduce the expected results of known samples on an annual basis.

between storing samples temporarily and storing samples *indefinitely*. Numerous publications discuss this innocuous seeming distinction (Nuffield, p.xiv-xvi,31 & 112-114; Simoncelli, p.282 & 290; ASLME, p.4; Krimsky, p.7). This occurs with good reason: there are many ethical issues that emerge from such a consideration. These issues are diverse, but can usually be summarized as:

1. The permanent inclusion of data in a DNAD can create social stigmatization.
2. The permanent inclusion of samples in a DNAD flouts the concept of rehabilitation, which is central to justice systems in both the US and UK.
3. Indefinite retention denotes indefinite surveillance through speculative searching.

Williams points out logistical difficulties in indefinite inclusion that extend beyond ethical dilemmas, suggesting that it might actually hinder law enforcement (Williams, p.552) through an excess of outdated or otherwise useless matches.

The issue of sample retention is an issue of privacy and autonomy. The privacy component of storage time is self-evident, having data in a DNAD restricts privacy, and the duration of this restriction varies based on the duration of the data's presence in the DNAD. Also of note is the fact that it will make one's data available should the DNAD be misused or information from it misappropriated through any mechanism or circumstance (Krimsky, p.7). Autonomy was previously discussed as the right to make oneself an individual—and, since having a fingerprint in a DNAD would restrict the parameters upon which an individual is defined to a great degree, it affects the right to autonomy. Such a restriction would include the psychological stress that the knowledge of having a DNAD stored might induce along with the stigma that is associated with such data storage. This weighs heavily on the concept of rehabilitation, which is fundamentally a psychological process rather than a physical one. Thus an individual's ability to rationalize being free or being 'past' a crime will be attenuated by the knowledge that one is still on the database. Equally valid is the argument that other crime



records will still persist after the individual has been rehabilitated, and yet rehabilitation is still taken to be possible. Determining whether or not DNAD data persistence yields undue weight in an individual's mind is not possible, however given the level the layman will elevate DNA to over other forms of identification, such as fingerprints, is an obvious consideration.

Another question can be raised by considering an argument to the absurd, a *reduction ad absurdum*. While current legality makes only the distinction between “indefinite” and “not-indefinite” storage time, what difference would be made in efficacy if the data was retained for 400 years, instead of indefinitely? What about 300 years, or 100? What of 40? 20? 15? The argument shows that because “indefinite” does not appear to have a reasonable difference from “400 years,” we derive an absurd result, that is, by showing that 400 is realistically no different from 300, or 200, or 199, and so on, that the premise of “indefinite” storage is absurd. This does not explicitly refute indefinite storage time, but, in its consideration, shows that such storage time merits a realistic, concrete number: relating to the statute of limitations, or the lifespan of the person with the data, or the point where the individual is decided by the state to be rehabilitated. Nuffield considers similar questions, contesting that the public interest might not be promoted significantly enough between 50-year retention and indefinite retention to justify such a timescale (Nuffield, p.31).

In previous discussion of ethical issues, justification for such ethical transgressions can be established if significant benefit can be found in supporting the cause of such transgressions.

And for data retention in particular there are numerous arguments that support it:

1. It combats criminal recidivism as repeat offenders are aware of their presence on the DNAD and thus the ease with which they will be identified.
2. It will aid in detection in that it will also include possible exclusion samples.
3. It will accelerate the process of conviction as crime scene samples will have a greater chance of being tied to an individual immediately. As Nuffield points out, this would

- reduce “the distress and cost” of criminal proceedings dramatically (Nuffield, p.50), thereby benefiting society.
4. Retention could alleviate the need for other, more controversial measures such as familial searching and ethnic inference through the mechanism proposed in (3).
  5. Retention will produce increased awareness amongst other criminals as more are appropriated into the DNAD permanently, thereby acting as a deterrent beyond criminal recidivists.
  6. Retention of certain data has exonerated many innocent individuals where new evidence was compared to stored data.

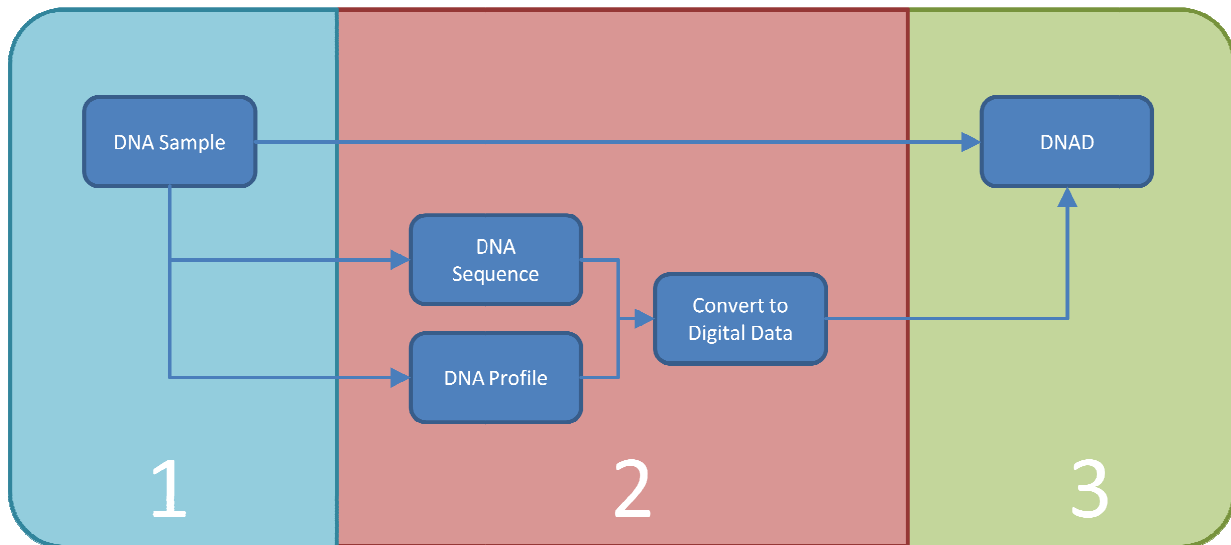
Counter arguments do exist, of course. For instance, (1) can be refuted by suggesting this will only lead recidivists to be more careful with regards to leaving samples at crime scenes. (2) and (3) might be countered by the increased inefficiency of the DNAD as it continues to grow with useless or outdated data, a problem mentioned previously as posed by Williams. (4) is invalid under the assumption that decreased usage of a specific measure does not decrease the ethical concerns associated with it, especially in light of the emphasis placed on equity in liberal societies. None of the points made by those in support of DNAD DNAF retention reconcile that individuals are being repeatedly and continuously searched as new DNAFs are uploaded to the database and back-checked, and this searching occurs *without* further due processes beyond the initial charge being *lald*. This potentially violates laws in both the US and the UK (The 4<sup>th</sup> Amendment and Article 8(1) of the European Human Rights Act, respectively). Nevertheless, the ultimate metric by which such claims, both pro and con, are to be judged is through statistical data. Currently, there is an insufficient body of research on the benefits of data retention (Nuffield, p.xvi). Despite this, many experts support this, among them the scientists who took part in the ASLME, citing increased reliability and quality control as the chief reasons for their support (ASLME, p.4). Upon the suggestion of expunging records of persons whose charges are dropped, it was also pointed out that the reasons for the dropped charges are of supreme

importance in making the decision, and simply expunging *everyone* whose charges are dropped is too broad.

#### 4.4.3.2 Storing Samples versus Storing Data

In addition to storage time, there is another parameter of DNAD that bears intense scrutiny. And, like storage time, the distinction that is drawn may appear subtle initially. In referring to the use of DNA in identification as a “DNA fingerprint,” it is possible to mislead the layperson. Krinsky draws the informational distinction between DNA and true fingerprints:

*“...fingerprints differ significantly from biological samples that provide DNA. Fingerprints are two-dimensional images of the raised portion of the epidermis of the fingertips. All of the information available from a fingerprint is there to be examined visually once the impression is made...by contrast, DNA, [must] be extracted from a tissue sample and mined for data” (Krinsky, p.2).*



**Figure 4.1** illustrates the steps between sampling and databasing. Step 1: Obtaining a Sample; Step 2: Mining the sample for data, and Step 3: Storage in a DNA database.

Thus, DNA has multiple levels of information and multiple ways of extracting that information. The step at which this storage takes place produces great variation in ethics associated with this storage. As a useful analogy, consider describing an individual. A DNAF is akin to a license

number: the number identifies that person uniquely, but imparts no data on the specifics of that person. Contrast this with a DNA sample, more akin to an image of that person: their appearance, their surroundings and perhaps even some behavioral traits and family relations may all be gleaned from such media. Obviously DNA fingerprints and DNA samples represent items with extremely divergent information density.

As clearly visible in figure 4.1, storing a DNA sample (such as the tissue itself) does not require mining, and mining may be done at the leisure of law enforcement. DNA sequencing and DNAF, however, are types of data mining, wherein the sample is analyzed and data is extracted from it. DNA sequencing is not a generally accepted form of DNAF, and is indeed quite different from DNAF, but is provided only as an example of other methods of mining DNA for data. However, both are techniques by which data is mined from DNA in a manner that can be stored digitally. Thus, a process is applied to the sample, data is obtained, and that data is stored digitally in a DNA database. Once this data is obtained, it can be analyzed, but no new data will ever be available. Conversely a DNA sample may be mined repeatedly in different ways as it contains the original, unprocessed information. Williams once again proves useful in this distinction, elaborating on DNAF (referred to as profiles):

*“[DNA] profiles are understood as powerful biometric artefacts (sic) but ones which carry little or no genetic data which would permit “diagnostic” inferences to be made about the medical, phenotypical or other personal attributes of the individuals from whom they were derived” (Williams, p.551)*

This is contrasted with the nature of a sample, which is explained by the British human rights advocacy group Liberty:

*“[DNA samples] potentially contain very much greater, more personal and detailed information about an individual [than a DNA fingerprint]. This may include highly private matters such as information about a latent genetic illness, or the birth gender of a transsexual person. It may even reveal behavioural (sic) tendencies, or important information about the individual that he did not even*

*know himself such as the true nature of his familial relationships. The 'knowledge' in relation to an individual's life that can be gleaned from DNA samples has no parallel in the history of science"* (from a submission by Liberty to the second hearing of the R v. Marper & 'S' case)

To elucidate this concept further, consider a hypothetical scenario wherein two countries construct DNADs. The first country constructs a DNAD (DNAD1) composed simply of the DNAFs created out of sample analysis. The other (DNAD2) stores both the DNAFs *and* the samples the DNAFs were created from. A scientist approaches both countries with a proposal to analyze the DNADs to see if it is possible to correlate violent tendencies with certain properties DNA. The scientist first searches for violent offenders who have been sampled. The scientist creates two groups, violent offenders and non-violent offenders. Because DNAD1 contains only the DNAFs of these groups, the data is very limited and only extremely weak correlations can be found. However, DNAD2 contains the DNAFs *and* the samples. The scientist randomly picks samples from both groups, analyzes these samples to determine which alleles are active or present in each group, and then looks for alleles that correlate strongly within the violent group but not within the non-violent group. The scientist then is able to identify alleles that *may* predispose an individual for violence.

The ethical implications of this are truly enormous. It is not inconceivable that the State to whom DNAD2 belongs will then screen every sample in DNAD2 for this allele or set of alleles. All hits are then flagged, and the individuals could be monitored in an attempt to preempt violent crime. This has frightening implications for what it means to have free will, and the presumption of innocence. Even more frightening is the slippery slope that this could lead to. What, for instance, is to become of newborns with these genetics? What if some ethnicities are found to have a larger number of individuals with this hypothetical genetic predisposition? This

could lend credence to some of the darker aspects of humanity; such as racism or eugenics. This hypothetical scenario, even if it were to take place, is considerably far off. Yet it does show the enormous differences between storing DNAFs digitally and storing samples. Despite the scenarios outlandishness, variants of it have been considered in many forms of media, from film to academic papers, for quite some time<sup>19</sup>.

There are other ethical issues associated with sample storage vs. DNAF storage that are more realistic and immediately applicable to modern times. In terms of the assumptions made for this discussion, sample storage primarily implicates privacy. Because the genome contains all genetic information about an individual, as distinct from simply identifying information that a DNAF contains, sample storage entails a much greater impact on privacy and notions of privacy. Information about genetic disease or predisposition to certain diseases can be identified from such a sample using existing technology—such information is not required by law enforcement in solving a crime except in extremely unusual circumstances. Similarly, information about an individual’s children, who might be innocent, can *also* be derived from the individual’s sample. In addition to privacy, it is possible to argue for the effect on autonomy that such storage might have. For instance, the same psychological effect that sample storage time produces could be replicated by the knowledge that not only is one’s DNAF stored on the DNAD, but one’s entire genome is there, as well. Nuffield summarizes these ethical issues effectively:

*“[It is] possible to sequence all or part of an individual’s genome from their biological sample, and therefore, the retention of biological samples requires much greater critical attention, and justification” (Nuffield, p.xv).*

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<sup>19</sup> The Nuffield Council produced a 258-page report on the ethics of behavioral genetics; see [Genetics and Human Behavior: The Ethical Context](#). The Oak Ridge National Laboratory also maintains a large website devoted to the ethics of human behavioral genetics, viewable at [http://www.ornl.gov/sci/techresources/Human\\_Genome/elsi/behavior.shtml](http://www.ornl.gov/sci/techresources/Human_Genome/elsi/behavior.shtml)

Non-ethical arguments against sample retention center around the considerable cost of such storage (Nuffield, p.42) and the space required. It is important to remember that biological samples, in contrast with many other kinds of evidence, must be kept frozen to prevent degradation. While DNA is quite stable at room temperature, it will show degradation over time compared to if it were frozen (Spear, p.5). Typically this needs a storage temperature of -20°C or -80°C. The difficulty becomes obvious considering CODIS' six-million-DNAF size: if all of those DNAFs had a corresponding sample, it would require many hundreds if not thousands of refrigerators to store. Additionally, while even a home computer can search and catalogue several million items with perfect accuracy and high speed, physically storing the samples would rely on *humans* meticulously keeping records, as mislabeling or misplacing a sample could result in serious legal consequences for any individual being convicted or exonerated based on DNA evidence.

Of course, there are compelling arguments for sample retention. A majority of scientists participating in the ASLME concluded that:

*“Sample retention was considered wise given concern about the reliability of laboratories responsible for testing, and the possible adverse consequences of incorrect records, particularly due to a sample switch in the laboratories”*  
(ASLME, p.4).

The ASLME raises an interesting question that, since sample errors can occur even without the added difficulty of sample retention, without sample retention can such errors be corrected?

Another argument for retaining samples pertains to the reality of appeals, retrials, and the challenging of such forensic data. Having the sample on hand could alleviate such concerns.

Retaining only unrepeatable samples, such as crime scene samples, which cannot be obtained again, is a commonly offered compromise that seeks to maximize benefit while minimizing risk.

Paradoxically, the British NDNAD removed some 125,000 samples derived from crime scenes

between 1995-2006, after convictions were made (Nuffield, p.55)—but does not remove samples derived from persons subsequently found innocent.

The FBI cites a number of reasons why sample retention is necessary, which include quality control, restoring the database if it were corrupted by some means, and, most importantly, applying new analytical techniques to samples as the techniques develop (Herkenham, p.381). After being asked by the Science and Technology Committee in regards to the necessity for sample retention (Trial 1), the House of Lords cited the convenience and a “number of samples which would previously have fallen to be destroyed but which were later found to match against stains found at the scenes of some very serious crimes” (Trial 2, p.6). The head of CODIS, Thomas Callaghan, agreed that it was necessary to retain samples, both to check old analyses and because the destruction of samples would be the equivalent of “freezing the database to today's technology” (Weiss).

Thus, after weighing the ethical and non-ethical problems and benefits, the ultimate determination in an ethical analysis is necessity. Currently, vague facts such as a number of samples slated to be destroyed proved useful are not sufficient to establish the value of sample retention on a DNAD. Nuffield similarly points out that there is a lack of empirical evidence supporting sample retention (Nuffield, p.xv), and contends that “fewer than 20 per cent of crime scenes are forensically examined and DNA DNAs are successfully added onto the NDNAD from just one in twenty of these examined scenes” (Nuffield, p.47), a fact that casts the cost-effectiveness of sample retention into serious doubt. Additionally, for many non-major violent crimes, the Home Office remarks “in many cases of minor interpersonal violence, DNA is relatively easily recovered, but makes no material impact on the subsequent investigation as the identities of those involved are frequently not in question.” ASLME states that some experts feel



that DNA technology, at present, is sufficient for any sort of identification and prospective sample retention, in the hopes of developing better technologies, is no longer necessary (ASLME, p.4).

This discussion determines that sample retention is indeed unethical at this time and with this present amount of empirical evidence. Consider what has been established: sample retention implicates major privacy concerns as well as some autonomy problems, thus necessity must be established to justify such ethical infringements, and since neither the US nor the UK—on whom the burden of proof lies—have produced sufficient empirical evidence to show that sample retention has been beneficial beyond vague statement, it is impossible to conclude that the necessity test has been passed. Consequently, because of the range of unacceptable future uses to which such samples might be put, it is not acceptable for such sample storage to exist given current knowledge of its usefulness.

#### **4.4.4 Mission Creep & Future Concerns**

In the context of DNA databases, the concept of “mission” or “function creep” goes by many names, but describes essentially the same phenomenon: the incremental (creep) expansion of the permissive functions (mission) of the national and state DNAD. In both the United States and the U.K. there has been concern over the expansion of DNAD (Daily Mail; Hirschler; Silverman; Abbott; Weiss). In this discussion, the initial function of CODIS and how that function has changed over time will be examined, with a focus on new legislation expanding its function.

The first DNA databases originate in the early 1990s, where they were established to combat sex offenders, on the basis that sex offenders are likely to repeat their crimes, and that

the nature of their crimes means that DNA evidence is often left behind (Krimsky, p.4; Weiss). Shortly thereafter, riding on the success of DNA several high-profile convictions, congress passed the DNA Identification Act of 1994, embedded in the Violent Crime Control and Law Enforcement Act of 1994. The act established the aforementioned CODIS in an attempt to facilitate information transfer of data and the amount of data available to law enforcement officials.

A bill introduced in October of 2003 by Republican Senator Orrin Hatch would significantly increase the number of samples being added to CODIS. The bill, called the Advancing Justice Through DNA Technology Act of 2003, contains a provision in title one (the “Debbie Smith Act of 2003<sup>20</sup>”) to amend the DNA Identification Act of 1994 to read, in lieu of “[it is permissible to obtain the DNA, for use in CODIS,] of persons convicted of crime”:

*“persons convicted of crimes, persons who have been indicted or who have waived indictment for a crime; and other persons whose DNA samples are collected under applicable legal authorities”* (Adv. Just)

The bill failed to reach a vote in the either house; however it was succeeded by a new version, having the same name but a new designation, H.R. 3214, along with identical proposals. With bipartisan support this bill made it through debate and the House, however stalled in the senate. In 2005, at the end of the Congressional session, it was cleared from consideration as per the law. Both S. 1700 and H.R. 3214 failed due in part to strong resistance on the part of a number of parties<sup>21</sup>. The president of the National Association of Criminal Defense Lawyers sent a letter on behalf of his organization to Orrin Hatch and Patrick Leahy asserted that “the legislation flouts the presumption of innocence, misallocates resources, and encourages racial profiling”

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<sup>20</sup> Named for Debbie Smith, a Virginian woman who was brutally assaulted and raped after being forcibly removed from her home on May 3<sup>rd</sup>, 1989. Her assailant was only identified six years later, in 1995, after a lab technician matched the DNA samples obtained from Mrs. Smith with a man already in jail for a separate offense. (Smith)

<sup>21</sup> Another bill containing the Debbie Smith Act was signed into law, H.R. 5107. See N.4.1 for details.

(Edwards). The failure of both bills changed in April of 2006 when the Justice For All Act<sup>22</sup>, a variant of the Acts proposed by Hatch, was passed and subsequently signed into law. The Justice For All Act contains the Debbie Smith Act previously mentioned, as well as the DNA Sexual Justice Act. Both of these expand the scope of CODIS, to include:

*“DNA for any federal felony as well as any DNA collected under relevant state law. Among other things, this provision would permit the inclusion of records from states that collect DNA profiles of people who have not been convicted of a crime.”* (ACLU)

By 2004, all states in the US were connected to CODIS. However, at this time, all submissions to CODIS were of violent offenders who had committed grievous crimes (Krimsky, p.4). As of April 2006, 11 states permit DNA to be taken from arrestees or suspects<sup>23</sup> (Grid). Thus, the term “criminal DNA database” become a misnomer, as the database is no longer intended just for the guilty, but instead also includes the innocent, inadvertently or not.

Because of the enormous amount of legislation that has been passed since 1990 creating and expanding DNA databases, going over each is infeasible. Figure 4.2, however, gives an overview of legislation and major events in the history of US and UK DNAD, with a particular emphasis on events considered landmark by DNAD watchdogs and civil rights groups.

As with all previous discussions on ethical issues in DNAD, the primary focus has been to weigh the personal rights infringements with the needs of the state, and therefore, the populace. This particular discussion will diverge from that format out of necessity. Much of the perspective yielded by such a discourse would be identical to those already discussed; therefore it is prudent to focus only on *unique* perspectives offered by the expanding DNAD legislation. This might appear paradoxical; but consider that previous ethical examinations have been after-the-fact. Thus, while the ethics of familial searching was discussed, it was already taken to exist; and the

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<sup>22</sup> P.L. 108-405

<sup>23</sup> California, Hawaii, Louisiana, Michigan, Minnesota, Nebraska, New York, Oklahoma, Texas, Vermont, and Virginia

ethical infringements imposed by it *becoming* a technique were not considered. Similarly, other such issues were considered, for the most part, in the present form. Little attention was given to the direction these might be taken in. In this section, examination will be given to them as they are the unique perspectives offered:

1. How such legislation came to be passed, and the ethics of passing it
2. Where such “mission creep” will, in fact, creep

It should be noted, however, that in a conference of leading authorities on the subject of DNAF/DNAD, the American Society of Law, Medicine & Ethics (ASLME) found that the current consensus amongst experts in the field was that “the number of ‘hits’ and ‘investigations aided’ are inadequate measures of the effectiveness and efficiency of the use of DNA databases for crime fighting” (ASLME, p.5) and suggested metrics that measured the number of crimes solved with DNAD that would have otherwise gone unsolved, the increase in speed and decrease in cost of investigations, the deterrence of crime, and the number of individuals police were able to eliminate from suspect lists without investigation.

**Figure 4.2:** UK NDNAD and US CODIS database expansion legislation timeline, 1990-2009

It should be noted, however, that in a conference of leading authorities on the subject of DNAF/DNAD, the American Society of Law, Medicine & Ethics (ASLME) found that the current consensus amongst experts in the field was that “the number of ‘hits’ and ‘investigations aided’ are inadequate measures of the effectiveness and efficiency of the use of DNA databases for crime fighting” (ASLME, p.5) and suggested metrics that measured the number of crimes solved with DNAD that would have otherwise gone unsolved, the increase in speed and decrease in cost of investigations, the deterrence of crime, and the number of individuals police were able to eliminate from suspect lists without investigation.

Currently, there has been no government-sponsored public discourse on the matter of DNAD expansion. This does not intrinsically violate any of the personal rights discussed as of yet: rather, it requires an assumption about the State derived from one already made. Consider that it was assumed that any State discussed shall be a State that exists for the good of the people, an entity such as this is what is meant when the State is referred to. Extending this by considering what is needed for a State to accomplish this obligation, we may conclude permissively that a State is composed of, and is informed by, the society it governs. This is hardly a novel concept; in speaking about the United States, Abraham Lincoln famously remarked that the United States government is a government “of the people, by the people, for the people.”

Now the conflict emerges. If DNAD legislation is designed to be “for the people,” then how has it been “by the people” if no discourse has been organized with regards to the legislation and how can such legislation be considered ethical? In short, it cannot: this is not an issue of infringing or modulating a personal right, rather, it is a fundamental change in how an item under consideration, the State, exists. It is a reasonable notion that this is not on the part of some “Big-

Brother” act of the State attempting increased control. Rather, one must note that DNAD technology legislation relies on input and feedback between many contrasting bodies, namely the political, the scientific, the judicial, and law enforcement. Thus such mission creep can occur even if the whole is not aware of it, since no overseeing body is present.

While public discourse is obviously not feasible on a large-scale for every piece of legislation, one that affects the rights of the population such as this one certainly requires it, especially one that can be seen to impinge on such things as privacy and autonomy, and the notions of rehabilitation and the presumption of innocence in the legal system. Unfortunately, the matter extends beyond mere lack of discourse. Examples exist where such legislation has been expressly hidden from the public. The DNA Fingerprint Act of 2005, which enormously expanded the inclusion criteria for CODIS, was embedded (Title 10, section 1004, contained in a single page, p.126 of the 176-page bill) in the reauthorization bill for the enormously popular Violence Against Women Act (VAWA, p.126). Such an attachment is known as a “rider,” and has existed and been used to pass legislation (or stop other legislation from being passed) “under the radar,” so to speak, for some time.

Logistical problems introduced by the new legislation similarly bear consideration. The increase in sampling qualifications has led to significant backlogs of testing, and may result in laboratory errors as the pressure on workers increases. California passed a bill in late 2004, Proposition 69, that enormously expanded the number of persons (including innocents) who are sampled and processed (Simoncelli, p.279). This led to equally enormous backlogs in their testing facility Richmond; on January 31<sup>st</sup>, 2007 the facility had a backlog of over 150,000 samples (CCFAJ, p.2). The facility has reported that delays of half a year are commonplace (CCFAJ, p.3). This has resulted in *completely unnecessary* tragedy and personal rights

infringement. For instance, Gail Abarbanel (a director at a Santa Monica UCLA Medical Center Rape Treatment Center) was cited in a California panel as describing:

*“...the case of a rape victim whose rape kit sat on a shelf, unopened, for several months... When it was finally tested, it produced a “cold hit” identifying a rapist who had attacked at least two other victims, one a child, during the period of delay.”* (CCFAJ, p.3)

Similarly, a man accused of rape was held seven months waiting for his sample to be tested before being fully exonerated (CCFAJ, p.3). Thus it is clear that, in addition to the ethics implicated simply by existing, this legislation can have significant affects on personal rights via the logistics of their implementation. Thus it appears the question of whether or not such legislation benefits the people has been in part answered: it can, in fact, hold up the criminal justice system. This is the proverbial “nail in the coffin” for such expansion legislation, as its only ethical justification is that it would improve the overall well-being of the citizens of the State which enacts it, and that has clearly fallen away. Whether or not such matters can be mitigated or not through increased technology is a possibility, however does *not* fall under the scope of current ethical discourse as it is not readily applicable.

This expanding legislation provokes the question of whether or not a comparable amount of legislation has been passed to protect the privacy and autonomy of the people. Everett points out a significant lack of corresponding “rights” legislation when such legislation is examined in the light of the voluminous DNAD expansion (Everett, 275). However, notable exceptions exist, such as the Genetic Information Nondiscrimination Act (GINA), signed into law by President George W. Bush on May 21<sup>st</sup>, 2008. Built largely off the precedent set by the Americans With Disabilities Act, GINA makes provisions (ironically) for individuals whose privacy has already been sacrificed from being unfairly discriminated against by employers or health insurers (*see* Fig. 4.2) on the basis of their genetic information.



The final consideration is perhaps the least complex of all ethical discussions thus far. The consideration is, is it ethical to allow the continued, largely unbridled, expansion of DNA databases? Its complexity is low due to the ease with which a forecast is applied to it: if it is allowed to continue at current rates, we might interpolate a curve of legislation that leads directly to a surveillance state. This concern, indeed the exact phrase, is cited numerous in literature on the topic (Simoncelli, Krinsky, Noble, Williams, Nuffield, Cho, Hirschler). The concept of a surveillance state is clearly at odds with the assumptions presented about personal rights, as it removes privacy all together as a property intrinsic to all persons.

#### **4.5 Chapter 5 Conclusion**

Nothing in ethics is simple; and much of that which is examined with the lens of ethics is fundamentally at odds. Thus, a balance must be struck. This balance has been repeatedly mentioned, and a perfect one might be unattainable. Essentially this balance consists of weighing the good of the *people*, using the assumptions necessarily laid down for the State, with the good of the individual, specifically on preserving the rights of the individual that are similarly assumed. The direction in which this balance leans, that is, whether the State must sacrifice or the individual, depends on ethical lenses similarly laid down: utilitarianism, elevating the good of the many above the good of a few, and libertarianism, elevating the individual above the needs of the State. Such examinations are not always fruitful neither are they always simple—it has been shown that not only is the premise of an item worth ethical consideration, but the logistical effects of such an item carries due weight. However, several conclusions are possible to approach such a balance.

What is absolute cannot be infringed upon. Ben Franklin remarked that those who would give up liberty to achieve security deserve none. Indeed, if the United States or the United Kingdom are to be liberal states that value the individual, some things cannot be sacrificed. This is not at odds with consequentialism: the consequence of obliterating the autonomy and privacy of the innocent is such that doing so would obliterate the premise of the State, and therefore simply cannot be done. Implicit in this is informed consent, which must be preserved regardless of the circumstance, as without it the assumptions cease to be *valid*. Similarly necessary is the concept of rehabilitation and the presumption of innocence; they too must be preserved if the entire system is to remain *valid*. In other words, if the State dissolves the very purpose it exists for, it is *invalid*.

Public discourse is the second pillar on which DNAD expansion and the allowance of a DNAD *must* be based upon. The public needs to be made aware of such technology, in so far as being aware of the nature of a DNAD and how a DNAD affects their personal liberties, so an informed decision can be made. This includes the evaluation of what science yields before it is put to use by any entity. Above all, as long as the people continue to regulate the DNAD that regulates them, ethical considerations null. This appears paradoxical, however one must consider what is implicit in informed, truly free decisions: autonomy. If autonomous persons validate the conduct of the State, then disallowing such conduct, regardless of the effect the conduct has in and of itself on the autonomy of the people, would represent a fundamentally greater violation of said autonomy.

So far, little to no public discourse has been made. In fact, there is even evidence of the government, specifically the FBI, attempting to actively discourage public discourse and public inquiry: The Los Angeles Times recently reported on the findings of a lab technician, Kathryn

Troyer, found “dozens” of potential matches using the software—which significantly goes against the reasoning of the FBI, who state that the chance of finding two matches are “one in 113,000,000,000.” This sparked significant interest in the topic of potential match statistics, but the FBI dismissed the findings as “meaningless” and has sought to block an inquiry into the actual statistical properties of the database (Felch) (for a possible mathematical resolution to these numbers, see footnote 16).

The groundwork has been laid bare in the previous four sections of this chapter; thus the discussion will now approach practical conclusions with regards to the ethical problems. These conclusions are of course the opinion of the author, and being such they cannot be established with the same rigor that the existence of ethical *issues* may be. Nevertheless, in light of the information presented it is possible to form reasonable opinions with regard to those issues. In making these conclusions, the concept of proportionality will be employed repeatedly. Proportionality, already mentioned in this discussion, denotes an action or response that is reasonable when compared to the actions purpose or that which provoked such a response. For instance, the use of deadly force by the police is considered proportionate if the offender is armed and threatening, but not considered proportional if the offender is unarmed and not threatening.

Obtaining samples without consent was shown to be controversial in 4.4.1.1. This is considered proportional by the author. The idea of a Social Contract, or at least the ideas that constitute it, have been around since ancient Greece: where Plato famously used the concept to argue for his own imprisonment and death penalty (Friend). In essence, it states that the liberties enjoyed by those in a society are allowed to enjoy them in exchange for the promise to act in a civil manner. In that sense, the Social Contract is a contract between the individual and society at

large. A criminal, being a criminal, violates this contract by committing a crime, and therefore is not (any longer) guaranteed the same rights as others in the society. One of the rights lost is not being required to give up a DNA sample without consent.

Taking samples from arrestees, who are not necessarily criminals, is not proportional. In doing this, the State invalidates the social contract and, for persons who are arrested but not found guilty, implicitly creates the label “less innocent.” Such a thing is not permissible, even if it would help the police solve more crimes (exactly how much more crime is up for debate as little empirical data has been gathered on the topic), because the Social Contract idea is quite simply premised on the notion that it is a contract, and not something the State can do away with when it is convenient.

Familial searching and phenotypic prediction are the most volatile topics that have been covered in this chapter. Together, they constitute a class of genetic analysis that will be termed “genetic inferring” from here on. Genetic inferring has the potential to be quite useful for fighting crime, although carries heavy ethical burdens, particularly where privacy and racial stereotyping is concerned. Phenotypic prediction does not appear to be useful as of yet. Arguments for this type of genetic inferring typically cite that warrants and police descriptions always include ethnicity, however this is specious: such descriptions include much other than ethnicity, and having ethnicity alone is not terribly useful. In fact, using phenotypic prediction has been implicated in at least one “DNA dragnet” that was shut down by the state due to its ethnic stereotyping (Simoncelli). Therefore, phenotypic prediction, because it only allows for exceptionally broad and not necessarily correct descriptions that can lead to racial marginalization and stereotyping, is not proportional.

Familial searching does not rely on ethnicity to select potential suspects, beyond the uneven ethnic representation already built in to CODIS and NDNAD. However this uneven ethnic representation is a problem with DNAD that lie elsewhere and do not reflect badly on familial searching. Familial searching does rely on several assumptions, some of which can be construed as being unethical. For instance, it assumes that criminality runs in families—something that suspect families may not be pleased about, especially when word of such a search reaches their peers in the community. However, statistics back up this assumption (*see* Harlow). With legislation to ensure the privacy of families under scrutiny, and to provision for the destruction of samples if a given member of the family is found to be not guilty, familial searching is proportional to crime fighting and indeed may be a useful tool to prevent crime, and finally allows for a DNAD to expand its usefulness in identifying suspects beyond those which are not in the database.

Whether or not samples should be retained or destroyed is a comparatively simple issue on which to draw conclusions. Once the DNAF has been taken from a sample, it is possible to identify and search for the DNA donor and therefore all the necessary properties an entry must have in order for a DNAD to work as expected are present. This means that the sample is no longer needed, and retaining it constitutes a large invasion of privacy considering the volume and sensitivity of the information contained in an individual's genome. Arguments for sample retention tend to center around quality control and reassessment of DNAFs if they should be contested. Quality control is a burden of the State, as the State manages the DNAD, and reassessment of a given DNAF can be done with a new sample that the offender will yield if the offender demands a reassessment. Therefore, offender sample retention is not proportional to the aim of crime fighting and indeed provides little benefit to the DNAD and incurs a large cost

owing to the expense of sample storage. Crime scene samples are an exception in that they are unrepeatable, they are unique to the crime, and because the sample was left during a crime there is no question of the innocence of the subject who left it.

However, the indefinite storage of DNAF is a significantly different matter. As mentioned previously, a DNAF stores no information about an individual's genes or their possible medical conditions, etc. (beyond the use of vague statistical inference techniques mentioned above). In other words, the information contained in a DNAF is very sparse and it is in no way determined by the person's genetic predispositions. Some have criticized indefinite DNAF retention as flouting the concept of rehabilitation: however, it should be noted that other identifying information will be retained by authorities (such as pictures, text records, etc) that weigh equally on the mind of a recovering offender. Since the retention of these has been judged to be acceptable in regards to rehabilitation, so does this discussion consider DNAF retention acceptable. Indefinite DNAF retention of individuals shown to be guilty is therefore judged proportional to the cause of crime fighting. As for those found innocent, their DNAF records should be destroyed along with other criminal records; this is because it is not proportional to violate the privacy (and storing a DNAF is certainly infringes on privacy) of an innocent individual. This follows from the concept of what the State owes the individual through the Social Contract.

The US and the UK both use private companies to aid in DNA analysis. In principle, this is perfectly proportionate given that the burden on state-run DNA labs has resulted in many adverse consequences, as mentioned in previous sections. Concerns of privacy and legitimacy can be mitigated effectively with increased government oversight, and a greater amount of randomized sample testing to ensure accuracy of the sample analysis. Enforcing a rigid materials

transfer agreement (as suggested by Nuffield), or MTA, would put a greater punishment on the mishandling of samples by companies, and therefore decrease the risk of samples falling into the wrong hands. Such MTAs are standard in much of bioresearch amongst private companies. Once these mechanisms are in place, this discussion views private company analysis as proportionate to the need for DNA analysis.

DNA Databases like CODIS and NDNAD carry heavy ethical burdens, and implicate privacy and autonomy in their function. It has been shown that these ethical burdens are not always alleviated by the benefits of the DNAD, and indeed much of what has been established by the DNAD is simply and unavoidably unethical. But two pragmatic points remain after all ethical analysis is said and done: DNAD has had a huge effect on forensic science and justice in general, and this effect has been, by and large, positive. Therefore some ethical burdens can be said to be mitigated by DNAD, in light of these benefits DNADs have provided society. Second, it is in the nature of science to continue to move forward independent of the political, ethical, or cultural climate in which it exists. Science will continue to generate technologies and techniques that can have ethical implications, but it is not possible to fault science for this, rather, the responsibility to consider technology carefully remains with us.

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## CONCLUSIONS

The importance of DNA fingerprinting in the current state of crime fighting cannot be overemphasized. It has revolutionized the nature of identification by providing a means of analyzing identity on an unprecedented level, a level that provides a degree of certainty beyond a reasonable doubt, indeed to a point of near mathematical certainty. It is similarly imperative to appreciate the complexity of the science from which the technology is derived; having its origins in a half century of biological advances since the helical structure of hereditary material, DNA, was first discovered. And finally, in a lesson taught to us collectively over and over throughout our history, a technology may not be judged solely based on its efficacy, despite the potential benefits that a technology might present.

Consequently this discussion subdivided the topic of DNA fingerprinting into several subsections, perhaps best described as the scientific, the procedural, the implementable, and the effectual perspectives. This of course involves considerable abstraction—however these abstract perspectives are grounded by careful evaluation of each in the real-world sense. The scientific perspective became a discourse on the fundamental building blocks behind the technique: that is to say, the molecular biology that lead to our capacity to determine identity through the use of DNA samples. Procedural details the intermediary techniques between the science, where the concept of DNA fingerprinting is established, and the production of an identity, when the technique comes to fruition. Such procedural detail includes the methods by which DNA samples are apprehended from suspects and crime scenes, and its analysis on an individual basis. Essentially, the steps required to generate a representation of the sample that can be used for legal purposes are discussed there. The permissibility of DNA fingerprints in a court of law is discussed, along with particular court cases that established the precedents for its modern-day

use. Finally, the effectual takes cues from the previous three perspectives in an attempt to construct a valid and equitable examination of the ethical and social implications DNA fingerprinting technology has on the population at large, beyond the courtroom precedent and the science behind it.

It was shown in chapter 1, whose primary concern was the scientific aspects of DNA fingerprinting, that the technique relies first and foremost on the genetic material embedded in nearly every cell of the human body. DNA, the famous official designation of said material, is an enormously long polymer (that is, a large molecule constructed of repeating or subtly varying parts ad nauseam) constituting a “code” represented four base pairs that repeat in a specific sequence. It is paramount that one understands that the DNA code embedded in each cell of an individual organism is identical, the consequence of this being that skin cells left behind by an individual can be examined, and, upon another sample being extracted from the individual at a later date, be compared to the new sample and shown to be identical. It is this property of DNA, as well as very specific regions on the DNA code that permits DNA fingerprinting to take place. These regions are known as STRs, or short tandem repeats. Thirteen of these structures—the 13 core loci—are the substrate examined by DNA fingerprinting.

A technique known as PCR, or polymerase chain reaction, utilizes enzymes that replicate the DNA code to generate a large number of identical copies of the specific STRs. This is done by placing the treated sample into a solution containing the constituent components of DNA along with the polymerase enzyme and primers, short sequences of DNA complementary to the target region of the code. The temperature of this solution is varied specifically as time progresses through the use of an automated system (a thermal cycler). This temperature variation modulates the behavior of the polymerase enzyme to produce an extremely large number of



identical copies of the DNA code that occupies the 13 loci.

The product of the PCR is then assayed. Using electrophoresis, the sample is separated by size, and the sample can finally be examined and compared to others who have undergone the same procedure. Upon finding a match, the technician may be reasonably sure that the two samples were derived from the same individual.

Other techniques use different regions of the DNA (in lieu of STRs), and even different types of mitochondrial DNA, were considered. Additionally, the uses of DNA fingerprinting beyond the courtroom, such as its archaeological and anthropological applications, have been examined.

Chapter 2 details the procedural aspect of DNA fingerprinting. First it is emphasized that the technician who obtains the sample is but a single component of a large mechanism of crime investigation, constituting many specialists who respond to a crime report and conduct their own, equally important data gathering. In order for any crime to be solved in an efficient manner, these parts must function as one, a body of techniques and individuals of which DNA sampling is but a component. Repeatedly established is the delicate nature of the techniques used to appropriate DNA samples. If DNA samples are not treated delicately, contamination may be introduced. Such contamination, DNA possibly from another individual, would throw the analysis by potentially yielding a bizarre mix of results that are useless, owing to the fact that ownership of a given mass-band of DNA is not possible to establish if there is more than one individual's sample present in the analysis. Several techniques are also introduced as possible methods of obtaining DNA. Finally, specific technologies as well as the protocols associated with long-term storage of DNA were explained.

Chapter 3 concerns itself with the legality of DNA evidence in the courtroom. DNA

evidence was initially a new science, which had to be established as a reliable and relevant piece of evidence. To ensure a fair trial, DNA evidence faced many admissibility tests, these included the “Frye standard,” the Federal Rules of Evidence, the “Castro Test,” the “Two Bulls Test,” the “Williams factors” and ultimately the “Daubert Standard.”

Once the basis for and requirements of such admissibility tests were laid down, other notable legal cases were mentioned. It was shown that DNA as a legal tool dated back to a British immigration case, *Sarbah v. Home Office*. Working directly with Alec Jeffreys, the pioneer of DNA fingerprinting, *Sarbah v. Home Office* holds the distinction of being the first case to use DNA to establish familial ties. DNA fingerprinting would not be used in a large-scale DNA screening (a “DNA Dragnet”) until the Colin Pitchfork Case, which concerned the tragic rape and slaying of two British women in two separate (but linked by forensic investigation) instances, separated by three years.

Other cases were considered, showing the murky legal waters treaded by DNA evidence, concerning especially the grounds on which DNA evidence, despite its impressive efficacy, may be ruled inadmissible and thus thrown out. The legal progression is thusly tracked to the modern day, a modernity where all states in the US permit the use of DNA fingerprints as evidence and even cold hits, generated by *a priori* reassessment of past DNA analyses, are permitted in court.

The enormous bounds that DNA evidence has leapt to achieve its position as the gold standard of either condemning or exonerating evidence is summed up in a lofty quote by the presiding judge of the *People v. Wesley* case, over two decades ago: “[DNA fingerprinting] is the single greatest advance in the ‘search for truth,’ and [toward] the goal of convicting the guilty and acquitting the innocent, since the advent of cross-examination.”

Finally, chapter 4 considered a significantly more abstract facet of DNA fingerprinting, specifically the technology's effect on the public in general. This was done through the lens of one of the most controversial implementations of DNA fingerprinting; that is to say, the agglomeration of a large set of DNA fingerprints into a DNA database, a data structure that arranges the DNA sample source with the DNA fingerprint analysis of that sample. Thus DNA databases allow for extensive cold searching, venturing into methods of cold searching that remain extremely contentious due to their possible effect on privacy.

The body of chapter 4 attempts to consider the ethics of DNA databases in a fair manner, and as is the nature of ethical issues, the decision is ultimately left up to the reader to decide what is ethically acceptable and what is not, that is, what ends are sufficiently beneficial to justify their necessary means. In spite of this, several opinions are offered up in each of the respective "sections" of DNA databases that fall under ethical inspection. It was decided that appropriation of DNA evidence as it currently stands is too broad, however it was acknowledged that the enlargement of DNA databases will generate more data for investigators. Similarly, such cold hit techniques like familial searching and phenotypic inferencing significantly and unacceptably impinges on the privacy of the individual, if ethical oversight continues to be as gratuitously absent as has been observed.

Nothing about DNA fingerprinting is simple, the science, the techniques, the legality, and the ethics presented by its very existence are sufficient to bewilder the layman to a point where such an individual would feel that understanding the procedure is an impossible Sisyphean task: every time some dark area of misunderstanding is elucidated, a hundred more misunderstandings become evidence. This is particularly unfortunate considering the benefit to science and to society that would be had if accurate understanding of DNA fingerprinting was widespread.

Nevertheless, by taking a reasoned and segmented approach to the topic the first two chapters provide an introduction to the topics that form the foundation of the technique, while the next two chapters yield a human perspective. Together, we aim to arm the reader with the knowledge and questions necessary to pursue a complete understanding vast array of topics behind the awesomely powerful tool that is DNA fingerprinting: questions built on science, but fueled by a humanist imperative that ultimately lead to a comprehension that is necessary in a rapidly changing technological world.