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DNA FINGERPRINTING

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ABSTRACT

Law enforcement has been greatly influenced by DNA fingerprinting. Understanding this new technology and its correct implementation are keys for its acceptance throughout society. The technology of DNA fingerprinting was investigated in the earlier chapters, while latter chapters focused on DNA ethics and legalities. We conclude that the acceptance of DNA evidence in U.S. courtrooms was not a straightforward process historically, but currently it can provide extremely powerful forensic evidence when properly performed.

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EXECUTIVE SUMMARY

The study of human genetics has grown exponentially in recent years, and from this scientific field and its accompanying techniques scientists have been able to determine the difference between individuals using DNA. Even though the *chemical structure* of DNA is not different for each person, the *sequence of base pairs* found in the genetic information are arranged differently for each individual. These are known as *polymorphisms* and are analyzed for repeating segments known as *Variable Number of Tandem Repeats* (VNTRs) which are between 9 to 80 bp repeats. To narrow it down even further, *Short Tandem Repe*ats (STRs) of 2 to 5 bp may be used to give greater ease to distinguishing between two individuals. It is in these differences that forensic scientists are able to analyze a DNA sample left at a crime scene for matches to known suspects.

Through the growth of technology used in genetics, samples used for extracting DNA have successfully been reduced to a small piece of skin tissue, a single hair, or a drop of blood among other bodily fluids. If there is not a large enough sample at a crime scene, however, a process known as Polymerase Chair Reaction (PCR) may be used to duplicate the DNA. Commonly, these DNA samples are used during crime scene investigations, paternity testing, military identification, and animal poaching.

Even though these technologies have been gaining acceptance in the courtroom, it took a while to truly become well received. Many different reasons contributed to this way of thinking. The issue of human error in collecting, documenting, storing, and

analyzing DNA samples all leave people weary to the complete benefit of DNA fingerprinting. There is a lot of responsibility on those who collect the evidence as well as those who process it, to use a standard method of gathering DNA. To encourage this, George Schiro, a forensic scientist with the Louisiana State Police Crime Laboratory, suggests these methods for documenting a crime scene before there is any collection of evidence: detailed notes by the investigator, photographs of the crime scene, a diagram or sketch of the area, and an evidence chain of custody form. Since preservation of evidence is paramount, it is recommended that crime scene processing be conducted by forensic specialists, as they have specialized training and experience, as well as access to equipment that can be used to detect potential DNA evidence.

The human error involved in DNA storage has also be an issue. Once collected, the DNA should be preserved in a dry, cold environment. While in the laboratory, cross-contamination, improper documentation, and non-standardized procedures may lead to greater loopholes in a prosecution's argument. To prevent this, the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) was created to bring standards and unbiased credibility to the facilities. With these steps towards standardization, DNA evidence will be more admissible in trials.

Landmark court cases define the conditions for accepting technical evidence (including DNA evidence) in court. These Landmark cases include: Frye v U.S. (1923) that established the Frye General Acceptance Standard for admitting any technical evidence in a courtroom, Federal Rules of Evidence 702 (1975) that allowed the use of expert witnesses where the Frye standard could not be met, Downing v U.S. (1985) that opened the way for pre-trial relevancy hearings, People v Castro (1989) that established a

three prong test to be used in pre-trial hearings and established the FBI's TWGDAM group for standardizing DNA methodologies, Two Bulls v U.S. (1990) and Daubert v U.S. (1993) that extended the pre-trial hearing to a 5 prong test.

Sensational cases, however, are likely where the public first heard about the impact of DNA testing and the extent to which is used. In the case of State of Ohio vs. Sam H. Sheppard (1954), made famous by the TV series "The Fugitive", and later the movie by the same name, DNA evidence found at the crime scene was recently used to acquit Sam Sheppard (the fugitive doctor) upon his second trial. In the O.J. Simpson Murder Trial (1995), seemingly conclusive DNA evidence to convict O.J. Simpson of murder was questioned in horrendous detail by the defense, covering issues such as evidence handling by untrained personnel, contamination by people who handled the evidence, and methods of DNA sample preparation, were all addressed in court. This case was important not just because of O.J. Simpson's popularity, but also because of the impact it had on subsequent DNA court cases that now rigorously applied the FBI's new TWGDAM standards for collecting, storing, and processing DNA evidence.

The ethical use of DNA fingerprinting and the storage of DNA information is becoming a heated public debate. In the United States, the era of national DNA databases was ushered in when, in 1998, the FBI went online with CODIS – the COmbined DNA Indexing System – a system for integrating local, state, and federal law enforcement agencies with the tools necessary to compare and exchange DNA samples electronically. Once a local forensic laboratory creates a DNA profile, the profile gets converted into a series of digits representing the kinds of alleles (gene types) at the 13 currently accepted CODIS forensic DNA loci. The numbers representing these alleles

get loaded into the lab's computerized database. Though originally designed as a national database, there are actually three tiers to its inner-workings: local, state, and federal, which all function in overlap.

The public's main concern is with who is being profiled in these databases. The debate focuses on whether to profile all individuals at birth, individuals suspected of performing a crime, or only convicted felons. Additionally, the type of information being stored is of major concern. People believe that the DNA profiles include medical information that will be sold to companies for profit. This incident happened in Iceland, where companies used the Icelandic's "relatively inbred genetic information" to correlate certain genetic sequences with predisposition to certain diseases. In actuality, the 13 CODIS loci include only "junk sites" that encode no known proteins, and contain no known medical information. Also, the DNA samples taken are destroyed so no further use or contamination is possible.

The authors of this IQP agree with the current Massachusetts legislation requiring convicted felons to donate their DNA sample to CODIS. But we would also like this requirement extended to include crime suspects; afterall, when an individual is suspected of a crime, other characterizing information is obtained and stored on record, such as regular fingerprints. The issue that now arises is the racial discrimination associated with DNA databases, and whether a general database is actually accurate for various ethnic groups. However, we conclude that the future likely includes the formation of various ethnic databases. Every person in the United States should not be profiled because it is believed that the individual's rights are more important than the benefit to society of profiling everyone.

PROJECT OBJECTIVE

The purpose of this project was to research current technology and trends relating to the forensic application of DNA fingerprinting, and describe how these affect society. Our goal was to help eliminate the public's doubt about this controversial new technology by delving into the ethical debate concerning its implementation. The focus was directed toward the layperson in order to target prospective jurors who evaluate the relevance of DNA evidence. This IQP will describe the science behind DNA fingerprinting, how DNA fingerprinting is performed, investigative techniques for acquiring admissible evidence, the proper ways of obtaining and storing DNA evidence, landmark court cases that dictated precedence for admitting DNA evidence in U.S. courtrooms, sensational court cases where the public likely first heard of DNA fingerprinting, and the ethics of DNA databases.

CHAPTER 1: INTRODUCTION TO DNA FINGERPRINTING

DNA

Scientific technology has recently made significant progress in the area of human genetics. The discovery of deoxyribonucleic acid (DNA) has proven to be momentous for science. Though the use of such knowledge is not fully realized yet, there is limitless potential for the subject. Through genetic studies, scientists may have the means to link parents to their children, cure genetically caused diseases, link criminals to crimes, and clone organs for transplant. However, moral issues have surfaced with the unveiling of such knowledge, and people have various misconceptions from a lack of accurate information that influences their opinions. In order to make proper judgment, one must understand DNA and the studies associated with it.

The chemical structure of deoxyribonucleic acid (DNA) is the same for every human. The double helical configuration of DNA forms chromosomes, the individual structures that contain genes (Brinton and Lieberman, 1994). 23 chromosomes are given to the child from each parent. The base of the genetic material is composed of four different chemicals: adenine (A), guanine (G), cytosine (C), and thymine (T). Specific bases are only able to pair with other specific bases complementary to their structure: adenine always bonds with thymine, and cytosine always bonds with guanine. Only four possible combinations may occur: A-T, T-A, G-C, C-G.

The bases are joined to sugars and phosphate to make nucleotides, whose order or sequence determines specific human traits. It is the order of the billions of base pairs in DNA that differentiates each person. According to Brinton and Lieberman (1994) by

studying the patterns of specific sequences, a study known as DNA fingerprinting, scientists are able "to determine whether two samples are from the same person, a related person, or non-related people". Below is an example of a DNA strand. It is read from the left of the upper strand (five prime or 5' position) to the right of the upper strand (three prime or 3' position). The lower strand is its complement. The strands of the double helix go in opposing directions (Brinton and Lieberman, 1994):

5' T-T-G-A-C-T-A-T-C-C-A-G-A-T-C 3'
3' A-A-C-T-G-A-T-A-G-G-T-C-T-A-G 5'

To further illustrate the chemical structure of DNA, the picture below displays the proper alignment of the base pairs. Dotted lines between bases indicate hydrogen bonds that stabilize the basepairs. The human genome consists of about 3 billion base pairs, of which 99.8% are identical for all humans (Axiak, 2003).

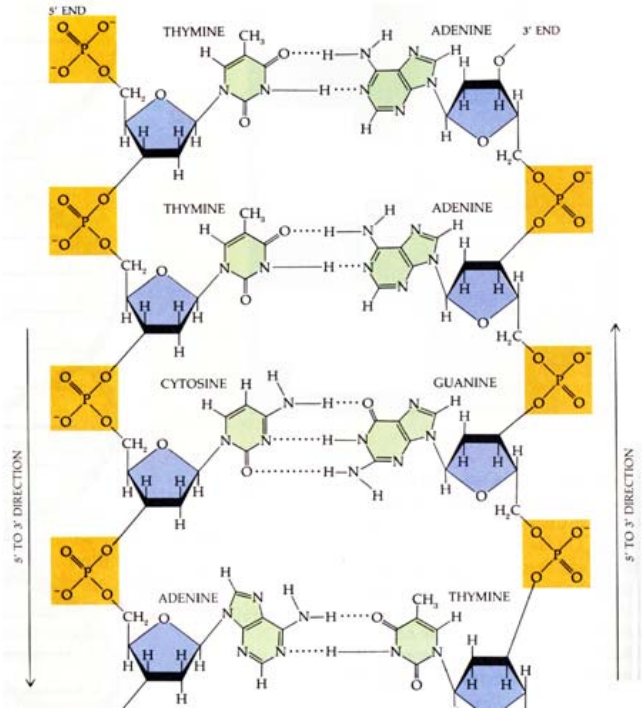

Figure 1-1: Specific DNA Base Pairing Featuring the Phosphate-Sugar Backbone (Double Helix, 2004).

The complementary strands of DNA are wound in a double helix, whose structure is shown below. James Watson and Francis Crick deduced the three-dimensional structure in 1953 at the Cavendish Laboratory in Cambridge, England (DNA from the Beginning, 2004).

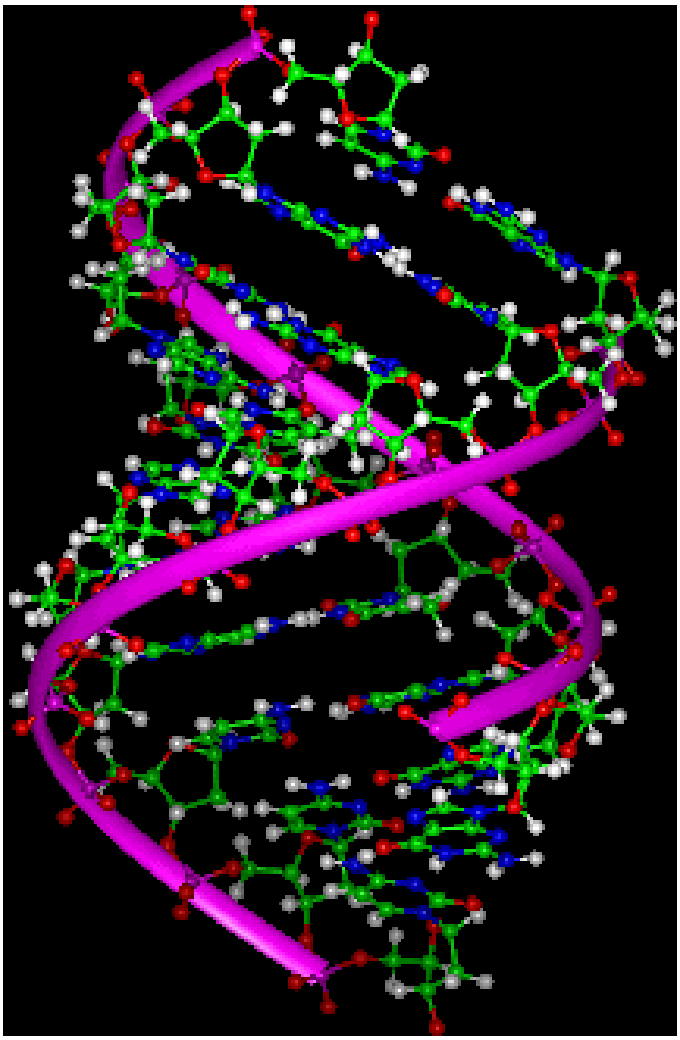

Figure 1-2: The Helical Lattice Structure of DNA (Nucleic Acids, 2004).

The field of DNA forensics analyzes specific regions (loci) of DNA that have been identified over the years to be highly different between individuals. Based on an

analysis of specific lock, scientists are able to distinguish between DNA samples coming from the same individual (identical matches), DNA samples coming from related family members (family relations), or DNA samples coming from non-related individuals. Single Nucleotide Polymorphisms (SNPs) are differences in the DNA sequence that occur when a single base in the genome is altered (Human Genome, 2004). To further elaborate on SNPs, they explain that:

> "…a SNP might change the DNA sequence AAGGCTAA to ATGGCTAA. 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… Many SNPs have no effect on cell function, but scientists believe others could predispose people to disease or influence their response to a drug. Although more than 99% of human DNA sequences are the same across the population, variations in DNA sequence can have a major impact on how humans respond to disease; environmental insults such as bacteria, viruses, toxins, and chemicals; and drugs and other therapies. This makes SNPs of great value for biomedical research and for developing pharmaceutical products or medical diagnostics."

DNA Fingerprinting

With improvements in our knowledge of DNA and its analysis, scientists are attempting to apply the innovative work towards society. It is important to reemphasize that the basic chemical composition of DNA is the same for all humans; however, it is the sequence of the various nucleotides at specific loci that differs for everyone. Studying the dissimilarities of the base pairs allows for the identification of DNA parallelisms, and

has applications to forensics. This identity testing is the newest, most powerful technique in forensic science, paternity testing, and the animal and plant sciences (Kirby, 1990).

RFLPs

When studying various samples, the loci are analyzed for their distinct characterizations. A locus (loci is plural) is a position on a specific chromosome where the different alleles (varying forms of a gene) of a genetic maker are located (The Biology Project, 1996). A typical DNA fingerprint analyzes about 11-13 different loci. Restriction Fragment Length Polymorphism (RFLP) was the first assay developed to show genetic differences between people. In this analysis, DNA is cut with a specific restriction nuclease that cuts DNA at a particular sequence. The cut DNA fragments are then separated by size by electrophoresis on a gel, and visualized by hybridization with a specific probe complementary to the band of interest. A SNP change in the DNA from one individual may gain or lose a restriction site, and this change can be visualized by an altered electrophoretic mobility of a specific band in the cut DNA (Levine and Miller, 2004).

Alec Jeffreys discovered a unique application of RFLP in 1984 as he searched for disease markers in DNA (Inman and Rudin, 1997). His theory concluded that no two people, except for identical twins, share the same genetic information. This information would later be applied to court cases where DNA recovered at the crime scene was used to link the criminal with the offense.

Analysis of the billions of base pairs in the human genome for each individual person would take years. However, according to Krawczak and Schmidtke (1998),

"using the widely accepted estimate that two homologous chromosomes randomly drawn from the human population differ at a frequency of 1 in 300 bp, sequencing a 15000 bp segment would guarantee that, with 99.9% probability, no pair of unrelated humans living on earth would be found to be identical."

The basis of DNA profiling is the use of Restriction Fragment Length Polymorphisms (RFLPs). Single base changes may create or delete specific restriction sites in DNA. These changes are visualized by isolating the DNA, cutting it with a specific restriction nuclease, separating the fragments by size on a gel, then detecting a specific fragment by hybridization to a complementary probe (DNA Typing, 2004). It is the unique configuration of the length of specific fragments that allows for individual identification.

Initially, DNA must be purified from its sample. Possible samples containing DNA include blood, hair, saliva, semen, or tissue (Meeker-O'Connell, 2004). Because of the different environments the specimen exists in when it is recovered, various types of isolation and purification processed must be made to ensure there is an uncontaminated product. A tainted sample is unusable in court.

Restriction enzymes are then used to cut up the huge genome into smaller, more manageable fragments. These enzymes are used to cut the DNA at specific base pairs. The fragments are then sorted by size using gel electrophoresis. An agarose gel is used to hold the samples and an electric field begins to separate the DNA. The DNA is separated by size because its negative charge pulls it towards a positively charged electrode, the larger fragments move more slowly than smaller ones. The size of each DNA piece may

be determined based on the distance traveled through the gel (Meeker-O'Connell et.al 2004).

The DNA fragments must be transferred to a nylon membrane if they are to be preserved. According to Meeker-O'Connell, "the positively charged nylon membrane is then placed on top of the agarose gel and used to sop up the negatively charged DNA fragment." To identify specific loci, it is essential to use the basic structure and chemistry of DNA. In order to find a specific VNTR sequence on a single strand of DNA, a probe made from the complementary sample sequence must be labeled with a radioactive compound. The probe is then able to bond to the DNA, and by using the radioactive tag on the probe, the location of the attached probe may be identified. Finally, an X-ray film may capture the radioactive images (Meeker-O'Connell, 2004). This process for DNA analysis was first applied to identifying specific viral DNA fragments by Edward Southern in 1975, and is termed a Southern blot in his honor. The figure below shows the basis of RFLP analysis from the initial gathering of DNA from a particular setting, to the final appearance of the sample onto the developing film.

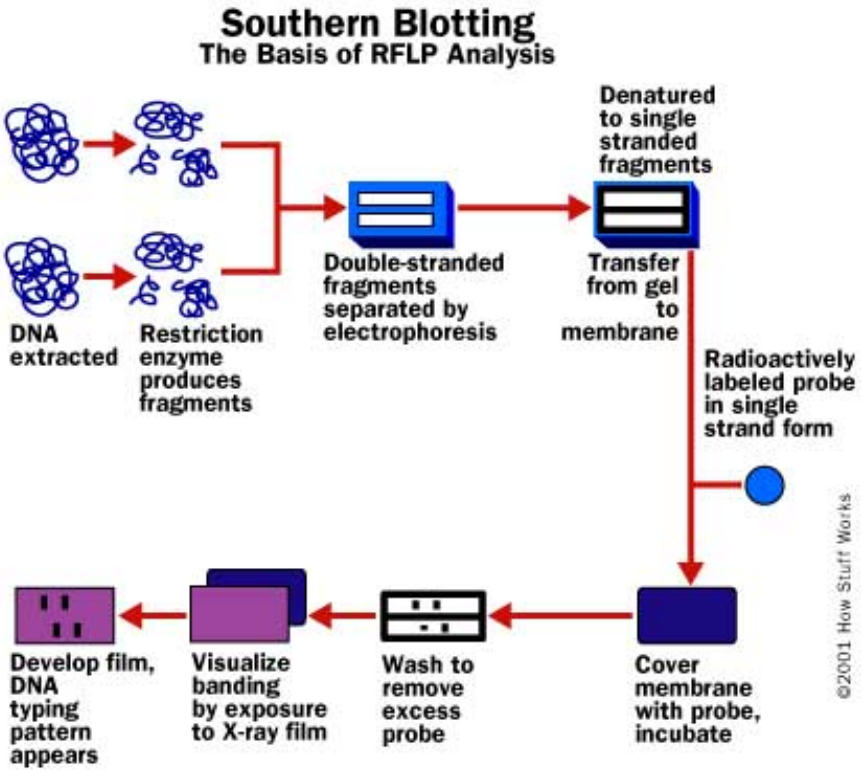

Figure 1-3: A Southern Blot Analysis (Meeker-O'Connell, 2004).

In order to run a successful Southern blot anaysis, a minimal amount of DNA must be present (see Table 1-1).

Sample Size for RFLP Analysis	
Blood	15 µl
Semen	5 µl
Skin	5 mg

Table 1-1: Sample Size Necessary for an RFLP Analysis (Micro 7, 2004).

VNTRs

Scientists have observed many repeating patterns in human DNA, and have devised specific grouping techniques to assist their efforts. Most of the repeats occur in groups of two, so are termed tandem repeats. The groupings of repeats in tandem are classified as satellite, minisatellite, and microsatellite, and they refer to the different levels of repetition and the length of repeated information (Krawczak and Schmidtke, 1998). The variability of this information makes each set of genetic information unique. Polymorphisms of 9 – 80 bp repeats are known as Variable Number of Tandem Repeats (VNTR) (Krawczak, 1998). The advantage of examining specimens of VNTR is the stability across generations (Frossard and Lestringant, 1999). They also determine unique sets of genetic markers for individual identification. VNTRs are often analyzed by RFLPs. Figure-3 below shows an RFLP analysis of several VNTR loci (ApoB, D17S5, D1S80, D2S44) from a variety of human cell lines (denoted across the top of the figure). Note that for a given VNTR locus, the length of the band analyzed differs for each cell line. The disadvantage of this technique is that it requires a relatively large amount of DNA for analysis.

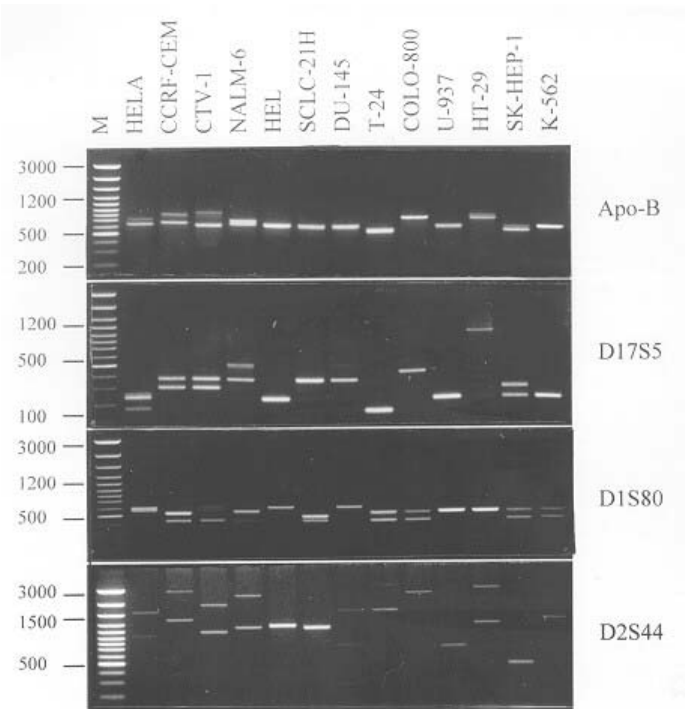

Figure 1-4: An RFLP Analysis of VNTR Loci from Several Human Cell Lines. VNTRs are denoted to the right of the figure. The cell line analyzed in each lane is shown at the top of the figure. The length in bp is shown to the left of the figure. (Fingerprint, 2004).

STRs

Short Tandem Repeats (STR) refer to repetitions of 2 – 5 bp (Butler and Reeder, 2004). Because STRs are so short, they are easy to amplify by polymerase chain reaction (PCR) (Schumm 1996), so RFLP analysis is not done for STR's. And because PCR amplifies the DNA, small amounts of material can be analysed. DNA differing in one of two alleles is able to be distinguished with great ease via STRs than with VNTRs (Butler and Reeder, 2004). He adds that STRs are plentiful – more than two thousand are suitable for genetic mapping.

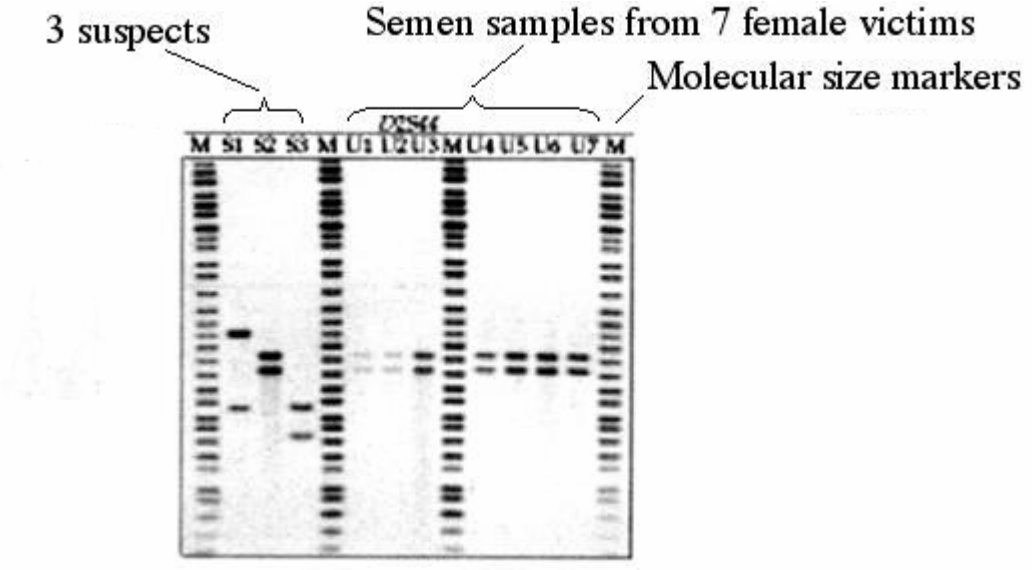

Figure 1-5: An STR Analysis of DNA in a Sexual Assault Case. Lanes "M" denote DNA size markers. Lanes "S1-S3" denote DNA from the 3 suspects. Lanes "U1-U7" denote semen DNA samples from 7 female victims. Note that the seven victims were all accosted by the same suspect, who matches suspect-2 (Molecular Genetics, 2004).

PCR

When there is an insufficient amount of DNA present in a given sample, more may be duplicated using a process known as Polymerase Chair Reaction (PCR). Also known as DNA amplification, PCR copies a small fragment many times to produce a large enough sample to run through an agarose gel. Having an ample amount of DNA allows proper analysis of the specimen (Inman and Rudin, 1997).

To perform PCR amplification, there must be a separation of the double helix. In a process known as denaturation, a fairly high heat is applied to the fractured piece of genetic material. Once the section is denatured, annealing of the DNA primers match defined locations by complementary base pairing. The raw materials of DNA are hooked together to create new DNA strands. The process is then repeated several times to produce a sufficient amount of sample for RFLP (Inman and Rudin, 1997). PCR is most

often used in STR analysis since the fragments of interest are very short, and easy to amplify. VNTR fragments are longer and more difficult to amplify successfully.

The process of DNA fingerprinting is relatively new to the field of science. It has, however, already become one of the greatest tools used today. With many practical applications, the knowledge attained allows many questions to be answered. As scientists unveil more of the mystery of the human genome, the possibilities of curing genetically disposed diseases become strikingly closer.

Through these various techniques, scientists have been making great advances in fingerprinting DNA. The ability to genetically link criminals to crimes, parents to children, and make attempts towards curing genetic diseases will be a great asset to mankind. There are many methods to profile DNA for analysis. By using tests such as Southern Blotting, DNA fingerprints are taken and compared.

Applications of DNA Fingerprinting

Forensics

Before the implementation of DNA fingerprinting, there was a distinct possibility that an accused criminal could be innocent of a crime. The use of eye witnesses, physical data such as clothing, and the personal statements from the convicted themselves pale in concreteness compared to DNA profiling. Solid genetic information has proven to be a breakthrough in court cases.

DNA found during serious crimes, such as rape and murder, have allowed investigators to determine the number of criminals involved and also if this person is a repeat offender. The analysis also allows the sex of the individual to be revealed (Kirby,

1990). With the information provided, law enforcement is able to perform a more thorough job on incarcerated individuals. Also, the use of DNA profiling helps prevent innocent citizens from being wrongly accused.

With the use of this technology, hopefully innocent people will not be convicted, while guilty individuals will have a higher probability of being convicted. It is important to realize that positive eyewitness identifications may be wrong, and that personal statements may have been offered by an innocent suspect to levy lighter punishments. With this acknowledgement, the presence of DNA is nearly the only conclusive evidence.

Paternity Testing

The necessity for determining parental ownership over kin has been an issue for many years. Since a child shares chromosomes from each parent, DNA testing is an appropriate means to validate the truth of a case. Court disputes are nullified once conclusive evidence supports either parent's claim. According to Kirby (1990), "thousands of paternity cases have been resolved using DNA analysis techniques and of these, on average, less than 0.1 percent continue to court." VNTR patterns are so specific that it is possible to reconstruct a parental pattern even if only the child's pattern and one parent is known. This type of analysis is commonly used when the father's identity is in question (Brinton and Lieberman, 1994). The following figure displays the results of two different paternity tests. The one on the left indicates that the alleged father is not related to the child because half of the alleged father's DNA fragments do not line up with half of the offspring's. Alternatively, the example on the right shows a positive match father to child.

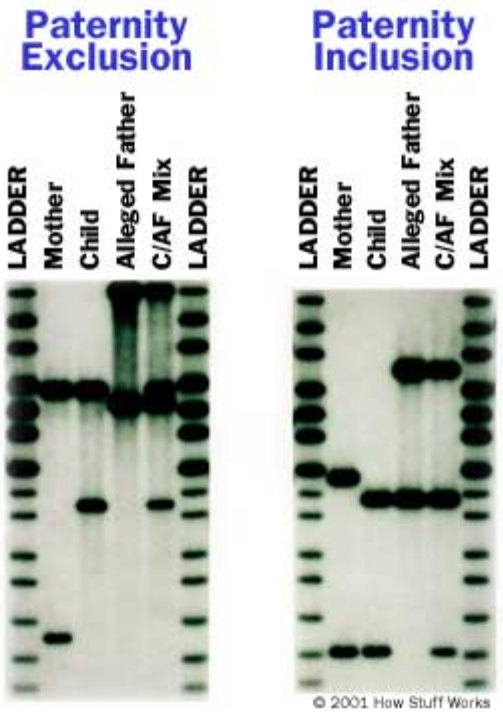

Figure 1-6: Two Different Paternity Tests (Meeker-O'Connell, 2004)

A major application for DNA genetics is in the analysis of genetically transmitted diseases. Genetic defects such as hemoglobinopathies have been found to be linked for many generations (Kirby, 1990). With enough research, scientists may be able to combat these diseases in a more effective way by aiding early diagnosis or predisposition.

Military Identification

When soldiers go to war, misfortunes may happen. When a soldier loses his or her life, a set of "Dog Tags" often gives their proper identification. However, this mode of identification may be lost through combat. Because of this, DNA profiling becomes important in correctly identifying the remains of people's loved ones.

On the fateful day of September 11, 2001, thousands of people lost their lives. By collecting victim references, direct sources of DNA for comparison (such as a toothbrush), and a relative reference, scientists are attempting to match relatives with their lost loved ones. It is still difficult to positively match indentities because the crime scene evidence (or even the provided direct sources) may be contaminated with someone else's DNA (World Trade Center Disaster Identification, 2002).

Poaching

Many people hunt for game, others hunt for sport. Either way, some people take their pleasure too far. When endangered animals become a target for hunters, DNA fingerprinting may allow a penalty to be assessed. If a tissue sample taken from a killed animal is found to match evidence in a gamesmen's home, such as food, a trophy, or a pelt, then a harsh consequence may follow.

Problems with DNA Fingerprinting

The most overlooked issue with DNA fingerprinting is the possibility of DNA contamination. Hopefully our society will not become so accustomed to the precision of DNA profiling that they overlook other more obvious problems with evidence collection. Also, a danger exists in criminal cases where a DNA sample from the perpetrator does not match the crime scene sample if the amplification method fails for various reasons (Kirby, 1990).

A large problem of DNA fingerprinting is the lack of knowledge on how to preserve a sample without either contaminating or ruining it. Investigators must now be

trained to handle the material with caution. New facilities must be provided to store the genetic material to ensure preservation. Because of the inconsistencies while collecting the samples from a crime scene, a judge may dismiss the evidence from the trial.

Databases of DNA banks have been established in many states for samples from convicted felons, and have been used successfully to identify thousands of cold hits to crime scene samples. The public often voices concerns that DNA databases are an invasion of privacy and security of the individual, however Kirby (1990) addresses this issue by claiming that, "the current technique for DNA typing reveals virtually nothing about the genetic make-up of an individual." So no medical information can really be obtained from a forensic database, so long as the original DNA sample is destroyed preventing further medical analysis. Additionally, it is difficult to judge how stringent these banks are with keeping their samples. It is easy to contaminate entire batches of DNA, and this tainting could prove to be detrimental.

Along these lines, people have concerns about their genetic information getting out to insurance carriers. There have already been cases against workers suffering from injury on the basis of genetic predisposition. Because of this, people are crying out for better regulation of how DNA may be used.

Court cases may also be biased with DNA profiling. If a criminal were to have a pubic defender, he would not have a genetics expert readily available for cross examination. Since there is not equal representation, there is a direct violation in the Constitution of the United States.

Future of DNA Fingerprinting

The current techniques for analyzing DNA are somewhat specialized, many future simplifications may promote ease of usage. Better means to preserve samples of DNA in secure facilities will hopefully make greater advances in the future. The ability to cure genetically inclined diseases would be a huge benefit to many suffering people for future generations. The possibilities of DNA fingerprinting is endless. The use of profiling has proven to be one of the greatest assets in the history of science and throughout criminal investigations.

CHAPTER 2: DNA FORENSICS

While the advent of DNA fingerprinting is relatively young, much work has been done already. Advances in technology, and consensus among scientists allow DNA evidence to be admitted during criminal trials more frequently than in the recent past. But laws vary from state to state, and even between federal jurisdictions. Differences in laws, what evidence is allowed, what practices laboratories use, and the proper care and custody of genetic materials affect the possibility that certain evidence may not be admitted into court. While many people view DNA fingerprinting as absolute forensic proof – more certain than a sign from God – the truth is that in practice, there are many variables that could make a conviction based solely on genetic evidence very difficult to obtain.

Because DNA fingerprinting is so deeply rooted in the technical sciences, the processes involved with it are not well understood by the general public, or law enforcement personnel. Therefore, extra care and precaution must be taken in all phases of harvesting DNA evidence, handling/storing, and especially testing. The Federal Bureau of Investigation warns that if DNA material is not properly documented, its origins can be questioned. If it is not properly collected, biological activity can be lost. If it is not properly packaged, it can become contaminated. And if it is not properly preserved, decomposition and deterioration can occur. ("Handbook of Forensic Services", 1999) A failure at any one of these levels can lead a good defense attorney to question the veracity of the proof against their client. And only the most informed of juries would be able to ascertain the truth in light of these discrepancies.

The Human Factor

So far we can say that the theory of DNA fingerprinting – that each individual has DNA with unique characteristics, and techniques exist that can visualize these unique characteristics in a reliable way – is sound. We can go further and add that scientists in general agree with the principles of genetic typing, and that its use today is well documented and accepted by the courts and law enforcement. But the biggest area of infallibility in DNA typing involves not so much the evidence itself, but the human handling of it. This vulnerability can be broken down into two main areas: the collection of the evidence by crime-scene workers, and the processing of the evidence by forensic laboratories. As the policies and guidelines developed by national standards organizations, such as the FBI and NIST, become implemented, crime labs will produce more dependable, less contested results. The heavier burden then will be on the crime scene investigators to do a thorough job so that the labs may obtain the most accurate results possible.

Although many precautions are currently taken by investigators to prevent mistakes, human error will always be a factor in the processing of a crime scene. The National Research Council (NRC) recommends that evidence samples be divided into several quantities soon after collection, so that if a mix-up were to occur, there would be backup samples to analyze. Comparing the DNA profiles of detectives at the crime scene, the victim, or a randomly chosen person, or a DNA profile from a database help to identify possible contamination of evidence. Ideally, forensic DNA analysis should be conducted by an unbiased outside laboratory, whose quality control and a low error rates may be

documented or certified by accreditation boards. DNA profiling can be a powerful tool in criminal investigations. Its success in the courtroom depends upon many factors, including:

- Proper handling of evidence
- Careful analysis by an unbiased forensic laboratory
- Fair and appropriate interpretation of the results
- Accurate and effective reporting of results to judges and jurors

(Wittmeyer, 2004)

Preparation at the Crime Scene

Okay, so what do crime scene investigators do if they find likely sources of DNA, and want to use it as evidence in court? We know that they have to make sure to document the origins of the sample found at a crime scene, as well as samples obtained from suspects and control specimens. George Schiro, a forensic scientist with the Louisiana State Police Crime Laboratory recommends these methods for documenting a crime scene: detailed notes by the investigator; photographs of the crime scene; a diagram or sketch of the area; and finally a chain of custody form (Schiro, 2001). Once this has been completed, he says, only then can work begin on the *collection* of evidence. Since we know that we want to properly collect and package evidence, the thorough investigator will likely have a toolbox of handy items to use during his investigation. Among the items they should have at the ready disposal are cotton tip swabs, manila envelopes with an information label, latex gloves, scalpels, distilled water, biohazard labels, and evidence identification labels, a UV light, tweezers and scissors (Ramsland, 2004).

Arrowhead Forensic Products, a division of Arrowhead Scientific, Inc., markets a simple to use DNA collection kit that comes with many useful tools for the collection of DNA evidence; such as tweezers, sterile gauze, and envelopes (see Figure 2-1). Many other kits exist, as well as a plethora of containers, tools and documents to assist in the collection of biological samples.

Figure 2-1: DNA Evidence Collection Kit

Another indispensable tool of DNA investigation is luminol, generally used to assist in the visualization of blood stains and patterns (see figure 2-2). 5-amino-2, 3-dihydro-1, 4-phthalazine-dione, or luminol as most people know it, is commonly used to locate very faint blood where attempts have been made by a suspect to clean suspected areas. It is generally applied with a sweeping motion from a spray bottle or pump sprayer. Luminol – $C_8H_7N_3O_2$ – a powdery compound, should be used fresh after mixing with hydrogen peroxide. After application, blood stains and patterns will glow a bright color and should be photographed immediately, as the effect will fade quickly. The downside to luminol is that it may potentially damage other evidence, so investigators should be careful to employ it only after exploring other identification and collection options (Harris, 1998). What you don't want to do is just start carelessly spraying luminol on every visible surface.

Figure 2-2: A simulation of luminol at work: Before spraying luminol (left panel), there's no sign of blood. After spraying with luminol (right panel), the latent blood traces emit a blue glow.

Preserving Evidence at the Crime Scene

Degradation and contamination are two major concerns in handling potential DNA evidence. The breaking down of DNA into smaller fragments by chemical or physical processes is known as degradation, while contamination is the introduction of foreign material to the sample. Potential causes of degradation are overexposure to heat and humidity, leading to the growth of bacteria, mold or mildew on a sample. Contamination can either be the mixing of two DNA samples together, or when a person inadvertently leaves a deposit in the evidence (for example, when someone walks on a blood splatter, or perhaps spills coffee on it, as an example). Either degradation or contamination can lead to false or un-interpretable results. Some general guidelines for the proper handling/shipping of evidence include the following:

- Avoid excessive exposure to heat or humidity – refrigerate/freeze if possible
- Never handle evidence with bare hands
- Never allow two items of evidence to come into contact with each other
- Air-dry evidence completely before packaging
- Package evidence in paper sacks or envelopes (avoid plastic bags)
- Package each item separately
- Ship evidence with dry ice or leak-proof ice packet (sample must remain dry)

("Evidence Submission Guidelines", 2002)

Since preservation of evidence is paramount, it is recommended that crime scene processing be conducted by forensic specialists, as they have specialized training and experience, as well as access to equipment that can be used to detect potential DNA

evidence. Because PCR analysis allows very small samples to be analyzed, greater attention to detail is necessary when collecting, and preserving DNA evidence. Specimens must be diligently handled and packaged separately to avoid possible cross-contamination. Someone sneezing or coughing over the evidence could inadvertently introduce contaminants to the sample. Because PCR duplicates strands of DNA, the introduction of contaminants or other unintended DNA to an evidence sample can be problematic. PCR is not selective about which DNA it acts upon. Therefore, when a sample of DNA is submitted for testing, the PCR process will copy whatever DNA is present in the sample; it does not distinguish between a suspect's DNA and DNA from another source.

The National Criminal Justice Reference Service offers these precautions to avoid contamination of evidence that may contain DNA:

- Wear gloves. Change them often.
- Use disposable instruments or clean them thoroughly before and after handling each sample.
- Avoid touching the area where you believe DNA may exist.
- Avoid talking, sneezing, and coughing over evidence.
- Avoid touching your face, nose, and mouth when collecting and packaging evidence.
- Air-dry evidence thoroughly before packaging.
- Put evidence into new paper bags or envelopes, not into plastic bags. Do not use staples. ("What Every Law Enforcement Officer Should Know About DNA Evidence", 1999)

It is important to keep the evidence dry, and at room temperature when transporting and storing evidence. Never place evidence that may contain DNA in plastic bags because plastic bags will retain damaging moisture. Direct sunlight and warmer conditions may also be harmful to DNA, so avoid keeping evidence in places that may get hot. George Schiro, a forensic scientist with the Louisiana State Police Crime Laboratory warns that "under no circumstances should evidence containing moisture be packaged in plastic or paper containers for more than two hours. Moisture allows the growth of microorganisms which can destroy or alter evidence." (Schiro, 2001)

Evidence Collection at the Crime Scene

What types of materials are investigators looking for when they scour a crime scene? Since every cell in every part of our bodies contains DNA, with the exception of red blood cells, almost anything can be a potential source. Teeth and tissues are good sources of DNA material, but it is rare that one would find these in a typical crime scene. Rather, the most obvious samples come from blood splatters (containing a mixture of red and white blood cells) and semen stains. Less obvious, but still important are saliva samples. These can come from extremely subtle sources: cigarette butts, chewing gum, toothbrushes, licked stamps and drinking glasses all retain saliva that can be analyzed. The knowledgeable detective will preserve food items, condoms, razor shavings, hair and fingernails. Even the victim's clothing could contain saliva or other body fluids that could lead to a suspect. Though not considered an ideal source, DNA profiles have been made from sources containing urine and feces.

When body fluids are found at a crime scene, preference is given to collecting the entire article containing the stain for sample analysis, as opposed to trying to swab or remove the stain. This approach provides for less handling of the evidence, reducing the likelihood of adversely affecting the sample. Going down the list in order of preference then is cutting out the area of the stain (again, when the substrate allows). Thirdly, investigators may swab fixed surfaces with clean cotton gauze or swabs moistened with distilled water. Ordinarily, water is an ingredient in the degradation of evidence, so remembering to air dry the swabs before packaging is critical. Finally, scraping a dry, crusty sample is the least preferred method, but can be used to collect material into a paper envelope. Problems with the scraping technique include chipping the stain into a powder, which may contaminate adjacent stains (Spear, 2004). Since scraping can only be done on smooth, non-porous surfaces, and since it is hard to retrieve the entire sample, most samples are more difficult to obtain in this manner.

The following procedures are offered by the FBI for collecting evidence for DNA analysis. Blood should be kept refrigerated using ice packs, not dry ice; do not freeze. If the blood sample is to be taken from a location, then it should be swabbed with clean cotton or swabs, and allowed to air dry before packing in paper or envelopes. Any bloodstained garment or objects should also air dry before wrapping in paper. Similar practices should be employed when collecting other bodily fluid samples, or fluid-stained objects: air dry before wrapping in paper for shipping. As far as solid evidence is concerned –teeth, tissue, or bones – freezing is recommended along with packing in dry ice. Wrapping in paper remains the preferred method, with the notable exception for tissues, or flesh – for which the FBI recommends plastic containers. Hair does not need

to be frozen or refrigerated, and should be packed in paper. ("Handbook of Forensic Services", 1999)

In an article written by Dr. Kimberly A. Lonsway, Research Director, National Center for Women & Policing, developed with contributions by Sergeant Joanne Archambault of the San Diego Police Department, the following guidelines are recommended for law enforcement on the topic of evidence collection:

1. Use clean latex gloves for collecting each item of evidence. It is recommended to change gloves between the handling of different items of evidence.
2. Each item of evidence must be packaged separately.
3. Stains must be thoroughly air-dried and packaged in sealed paper envelopes or paper bags. To dry stains, a hair dryer can be used on the coolest setting. For large amounts of liquid, a fan can be used.
4. Used condoms should be collected and placed in a sterile tube. The tube should then be frozen until analyzed. If a sterile tube is not readily available, officers should make sure - at a minimum - that the condom is allowed to air dry before packaging. Several layers of paper bags can then be used for packaging.
5. For proper chain of custody, all packages must be marked with the case number, item number, and date. Packages must also be initialed across the seals.
6. If stains must be transferred from an unmovable surface (such as a window or sidewalk), sterile cotton swabs and distilled water may be used.
    A. Photograph the surface with a ruler before swabbing. Lightly moisten the swab with distilled water.

B. Rub the stained area with the moist swab until all of the stain is transferred to the swab. If one swab is insufficient to collect all the stain, use additional moist swabs to collect all of the stain.

C. Two additional swabs should be collected as substrate controls for DNA tests. Swab #1 should be moistened and used on an unstained area adjacent to the stained area. Swab #2 should be provided with nothing else on it but the water used in the collection process.

D. Prepare properly marked envelopes or paper containers for the swabs.

E. Air-dry the swabs without permitting them to touch one another. If time requires, the swabs may be placed still moist in paper envelopes. (Glass or plastic containers should never be used. Paper containers allow moisture to escape which helps to prevent bacterial degradation of the DNA.)

F. Place swabs in appropriate separate paper containers, properly marked for identification.

G. Scraping dried stains instead of swabbing should only be done if the surface is perfectly smooth and the scraping will result in almost no loss of material. For example, a stain on a smooth vertical surface can be collected (after photographing with a ruler in the picture) by folding a clean sheet of paper in half and taping the top edge of the paper to the surface directly beneath the stain. With a sterile scalpel blade or unused single-edged razor blade, the stain can be scraped into the fold in the paper. Then carefully remove the paper from the surface, remove the tape, fold the paper into a packet, seal with evidence tape and initial properly.

7. Evidence which is incapable of drying such as pieces of tissue, organ, bone, liquid urine, vomit, or other biological material should be packaged separately in an air tight container. The container should be sealed and properly marked for identification, then immediately frozen and kept stored until analysis. Formalin or formaldehyde should never be used to preserve any biological evidence because these chemicals degrade DNA. (Lonsway, 2001)

Summary of Collection Procedures on Known Tissue Types

			Packing Environment		Storage Container				
Type	Amount	Air-dry	Refrigerate	Freeze	Clean paper	Envelope	Plastic	Cold Packs	Dry Ice
Blood	2 5mL tubes		X					X	
Blood on person	cotton swab	X	X		X	X		X	
Blood in snow	cotton swab	X	X					X	
Blood in water	cotton swab			X				X	
Bloodstains	cotton swab	X	X		X	X		X	
Semen	cotton swab	X			X	X			
Fluids from victim	rape kit		X						
Bucchal (oral)	cotton swab	X			X	X			
Saliva	cotton swab	X			X	X			
Urine	cotton swab	X			X	X			
Hair	fragments	X			X	X			
Tissues	1-2 in^3			X			X		X
Bones	3-5 inches			X	X	X			X
Teeth	any			X	X	X			X

Table 2-1: Source: FBI Handbook of Forensic Service**s**

Storing DNA Evidence

Because dryness and lowered temperatures reduce the rate of bacterial degradation of DNA evidence, most biological samples are best preserved when stored dry and cold. In her report, Successfully Investigating Acquaintance Sexual Assault: A National Training Manual for Law Enforcement, Dr. Kimberly A. Lonsway offers these guidelines for the proper storage of genetic evidence: "With the exception of liquid whole blood samples, the colder the storage the better. For dried stains, material should be

frozen (-20 degrees C) or refrigerated (4 degrees C) in separate paper containers. Dried stains which are very old and have been stored at room temperature for months or years will obviously not be hurt significantly by additional short-term storage at room temperature. Nevertheless, it is recommended that these samples be stored cold until they can be analyzed. For non-dried tissue such as bone, liquid urine, or other non-dryable biological material (except blood standards), these samples should be kept frozen (-20 degrees C) in separate air tight containers. Glass containers should be avoided as they can break when frozen. For liquid blood standards, these samples should be kept refrigerated (4 degrees C) in their original glass tubes. They should not be frozen."

Forensic Lab Handling Procedures

The second main area of concern is the introduction of error at the testing facility. Many of the same errors made at a crime-scene may occur here, also, such as cross-contamination. But some facets that defense lawyers focus on are not errors so much as failures: failure to run scientific controls; failure to document what work was performed; failure to follow established guidelines. Skewed test results from analysts who hope to help the prosecution win its case are a detriment to a lab's reputation. The science of forensics is really put to work in the lab, as many agencies have produced a wealth of documents to aid in the creation of procedures for handling and processing DNA, as well as determining a statistical model for the interpretation of results. Compliance with a national standards institute's recommendations, such as the National Criminal Justice Institute, is important for a lab's prominence and integrity, as is accreditation.

Founded by the FBI, the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) was created to bring local laboratories and the FBI laboratory together. The Crime Laboratory Accreditation Program is a voluntary program in which any crime laboratory may participate to demonstrate that its management, operations, personnel, procedures, equipment, physical plant, security, and personnel safety procedures meet established standards ("About ASCLD/LAB", 2004). Accreditation offers distinction in the field and, in theory, shows that a lab is committed to unbiased scientific discovery, but this should only be one aspect of a lab's overall quality assurance program. Proficiency testing, continuing education and the development of laboratory management principles should all be part of a laboratory's ongoing effort to provide the courts with the highest level of accuracy and fact possible. The process of self-evaluation which leads to accreditation is in itself a valuable management tool for the crime lab.

Of course, the defense lawyer is going to argue that the evidence is tainted, or that the meaning of the scientific conclusions was poorly represented by expert witnesses. Attacking crime labs often involves claims of contamination, a poorly trained or inept technician, and conspiracy. Was the examiner really working for the prosecution? Could bias be inferred, or was the evidence planted? Some areas that defense attorneys typically focus on are:

- Cleanliness – is the lab regularly maintained, and properly ventilated?
- Contamination – do containers get properly cleaned? Do employees wear protective clothing?
- Calibration – is equipment serviced and checked regularly?

- Access – can unauthorized persons gain access to the lab or storage areas?
- Independent testing – do supervisors occasionally verify results, or have another employee do a blind test? (O'Connor, 2004)

To protect against this sort of attack, and prevent even the slightest tarnish to its professional reputation, all crime labs should have a solid program for achieving and maintaining the highest quality possible. Key ingredients to a successful quality assurance program is adherence to a documented system which addresses issues such as organization, personnel qualifications and training, facilities, evidence control, equipment calibration and maintenance, safety, and auditing. Everything that a lab is supposed to do should be well documented, and everything that a lab does in fact do should be well documented. The importance of observing industry standards in this regard cannot be overemphasized. The proper mix of these ingredients will lead to less speculation or suspicion about a laboratory's conclusions regarding evidence.

Summary

DNA typing is an exacting science – its theory, and usefulness has been well documented and widely researched. Though new technologies and further discovery in this area are likely, we can safely rely on the known foundations of this important scientific discovery. But, human error proves to be the Achilles' heel in this powerful technology. Potential DNA evidence can be found in the most understated of locations – toothpicks, fingernails, even a bullet which passes through a person. By thoughtfully approaching a crime scene, with the right combination of experience, training and tools,

officers and investigators stand the best chance of finding, collecting, and preserving DNA. Following well established standards and procedures, a forensic laboratory will harvest useful results, and distance itself from impropriety. And finally, proper explanations and instructions to juries will help them weigh guilt or innocence.

Suitable preparation and documentation in all phases will help to eliminate suspicion about shoddy police work, biased lab results, and wrongful prosecution and conviction of innocent people. Appropriate handling and storage procedures assure us that evidence will still be viable for future use when advances in the discipline allow for better or more accurate testing. Observing standards and guidelines from respected bodies, such as the Federal Bureau of Investigation, and a focus on human contact in the two main areas of handling, crime scene and laboratory, will ensure that science and truth prevails.

CHAPTER 3: LANDMARK DNA CASES

Some criminal cases have greatly impacted the procedures used in subsequent cases. These cases are considered landmark because the procedures approved at these trials set the standard for subsequent cases. The following landmark cases were essential to the progressive use of DNA fingerprinting in U.S. courts as a viable method of prosecuting and defending criminals. In these cases, the *procedures* for allowing technical evidence in the trial were as important as the evidence itself. If the procedures or outcomes of these cases had been different, DNA fingerprinting may not have become a trusted and respected method of evaluating evidence. The following examples are a sample of cases where forensics and DNA fingerprinting were the foundation in which the criminal cases were built. The result influenced future cases, and made DNA evidence revolutionary to the criminal justice system.

1923, Frye vs. United States:

The Frye vs. United States case of 1923 was one of the first criminal cases to set a standard for accepting technical evidence in a U.S. courtroom. In this particular case, the method in question was the then new polygraph test, whose theory stated that a person's physiological parameters involuntarily changed when telling a lie. In Frye vs. the U.S. the presiding judge threw out the polygraph testimony because the new technique had not been fully accepted by scientists (Junk Science, 2004). The judge's

decision was detrimental to Frye's case because Frye had taken the lie detector test and passed. The case was instantly a landmark because it set the precedence that any new technology must be *generally scientifically accepted* to be admitted in a U.S. court, and many subsequent cases refer to this *Frye standard*.

Actually, the Frye case provided some drawbacks to the admission of scientific evidence in court cases because it required any new technology to gain general acceptance before it could be used as proof, and this standard was hard to achieve and prove. Nevertheless, the Frye standard remained in effect for decades until partially replaced by the Federal Rules of Evidence.

1975, Federal Rules of Evidence 702 (Rule 702):

The federal rule of Evidence 702 specifically deals with the validity a testimony by an expert has. It states that:

"If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case." (Rule 702., 2000)

The judgment under the new rules helped soften the difficulty required to

achieve the Frye standard for the use of new technology in the courtroom. The case of Frye vs. U.S. in 1923 provided drawbacks to the admission of scientific evidence in court cases since the so called "general acceptance" of a scientific technique used in a particular court case was hard to achieve and prove beyond reasonable doubt. The confusion and difficulty in judging the validity of technology forced the judicial system to set guidelines that would allow "expert witnesses" to testify about the validity of a given technique. The document itself was approved on January 2, 1975. It was amended multiple times by both the Untied States Supreme Court, as well as Congress (Federal Rules of Evidence, 2002). In essence, the outcome of this particular case resulted in an amendment in the court system to define expert testimony and forensic evidence derived from technology which impacted many future criminal trials.

1985, Downing vs. US:

In this case, Downing vs. U.S. 1985, John W. Downing was charged with mail fraud, wire fraud, interstate transportation of stolen property as well as aiding and abetting. John Downing used a fictional company known as the Universal League of Clergy, ULC for short, as a reference for credit (US v Downing, 1999). He would then charge products from trade shows. The vendors would assume the ULC was a reliable company because of their references to many mailing addresses. However, because the company was fraudulent, the vendors were not able to collect payments for the products. When Downing was finally caught, many vendors were willing to testify. With so much evidence against Downing, he had only one possibility of getting away

with a conviction. He and his lawyers tried to prove that the eyewitnesses were unreliable and therefore could not be used as a means of determining his guilt. The defense lawyers argued the eyewitnesses could not give reliable testimonies because their interaction with Downing was so brief. Despite the defendant lawyer's best efforts, in 1982 the jury found Downing guilty of all charges, except for interstate transportation of stolen property. In an appeal, the United States Court of Appeals attacked the outcome of the case citing the court's refusal to admit expert testimony that would discourage the acceptance of the reliability of the eyewitness accounts used in the trial. This ruling could have had a dramatic effect on the outcome of the case. Again the judge threw out Downing's case and the original guilty judgment stayed. The reasoning was that the expert testimony against eyewitness evidence did not meet the Federal Rule of Evidence 702 (US vs. Downing, 1999). The US vs. Downing, instantly became a respected and landmark case. This was again the result of a ruling based on what is considered expert testimony.

1986, Colin Pitchfork Case:

Another landmark case, named the Colin Pitchfork case, took place in England in 1986. It was the first case in England's history where DNA fingerprinting was applied to a murder investigation. The case began in 1983 when a fifteen year old, Lynda Mann, was found raped and murdered in the town of Narborough (Batt, 1999). Several years later, a second victim was found in a similar condition in a nearby town. Since both victims were found along a footpath called the Black Pad, people began labeling the

killer the "Black Pad Killer" (DNA Profiling, 2004). The authorities had almost no leads, and the search for the killer was not progressing except for Alec Jeffrey's a geneticist, who had developed a process that could possibly crack the case as well as revolutionize the court system in England. The new process was called RFLP (Batt, 1999). This process could link an individual to a crime by comparing a sample of blood, semen, saliva, or hair.

Since each person has unique DNA, the testing could prove that a suspect was at the crime scene or even committed the crime. In this case since the victims were raped, investigators were particularly interested in semen. If Jeffrey's process was correct, the police would be able to get DNA samples from the victim and use the samples later to compare to any suspects they might find, thus proving the true killer's guilt (DNA Profiling, 2004).

The police decided to try the new DNA fingerprinting system despite their doubt that the process was even possible or would be considered reliable. Since there were no strong suspects in the case, police decided to get DNA samples from all the local men who did not have a viable alibi for the nights of the murders. Police were not really planning on finding the killer during the testing, but were more interested in those men who did not readily what to give their DNA samples to the police (Batt, 1999).

The strategy was successful as police were tipped off by a local woman who overheard a man talking about how he took the test for another man. The man, Ian Kelly, was questioned and admitted that he did indeed take the test for a fellow worker named Colin Pitchfork. Ian Kelly told police that Pitchfork's excuse for asking him to take the test for him was that he had already given his sample for another friend and was afraid of

getting in trouble if an identical sample was discovered (Batt, 1999). Police picked up Pitchfork for questioning about his whereabouts during the murders. When police questioned him he admitted to both murders. Pitchfork's reasons were simply that the victims were just at the wrong place at the wrong time. Pitchfork also plead guilty in court and received a life sentence (DNA Profiling, 2004).

This case was revolutionary for two reasons. First it was the first case in which DNA was used to convict a criminal. Secondly it was also the first time in which innocent suspects were cleared when their DNA did not match the killer's DNA.

1988, Andrews vs. Florida:

Police departments in the United States started researching DNA fingerprinting after watching the success in England. Michael Baird, a forensic specialist, was contacted by a Florida police department to help with a case. Tommy Lee Andrews was being charged as a serial rapist, and the state of Florida wanted to use DNA fingerprinting to convict him (Ramsland, 2004). This case would be the first court case in United States' history in which DNA would be used for a conviction.

The rapes began in May of 1986. Nancy Hodge was raped at knifepoint in her Orlando apartment and her purse was stolen. The rapist did not let her see his face. During the next six months twenty-three women were raped. Just like the first rape, the man did not let any of his victims see his face (Ramsland, 2004). Since no one could positively identify him, the only way to convict the assailant would be to connect him to the possessions he stole from each individual victim. The chance of finding any of

the victims' personal property would be a very difficult task and probably would not be sufficient to lead to a conviction. DNA was the perfect tool to use in the rape cases because it was nearly impossible not to leave any DNA around a crime scene. Two fingerprints were left on the window at one of the crime scenes, and Andrews was identified as the rapist after he was arrested for prowling (Ramsland, 2004). His fingerprints were matched to the ones left at the scene, and his DNA matched some semen samples. Officials were sure they had their rapist. However, knowing and proving would be two very different cases, especially in serial criminal cases. Serial cases are difficult to prove because there is so much reasonable doubt and circumstantial evidence to try and connect several crimes.

Still when the DNA from Andrews was sent to a lab along with samples taken from the victims, the match was obvious. Since DNA fingerprinting had never been used in the United States before, the process had to go through a series of hearings to prove its validity before it could be used in court to convict Andrews (Ramsland, 2004). After a long and arduous set of hearings, the court allowed the DNA to be used in the case. The first rape case resulted in a hung jury due to a mishap by the prosecutor. However, Andrews was convicted of the second rape and received 22 years. Later prosecutors charged Andrews with the first rape once again, as well as others. DNA linked him to all the murders and Andrews was convicted of serial rape. This elongated Andrews's sentence from 22 years to 115 years (Ramsland, 2004).

The case of Andrews vs. Florida quickly became a landmark case being the first of its kind in America. Other convictions could now be made using this case as a reference. The DNA fingerprinting process opened the door to a whole world of

evidence never realized before. It quickly became one of the strongest conviction tools a prosecutor would have.

1989, 1991, 1993, Daubert v Merrell Dow Pharmaceuticals:

Daubert vs. Marrell Dow Pharmaceuticals was another case involving scientific reliability. Several parents sued Merrell Dow Pharmaceuticals accusing them of causing birth defects in their children from a drug called Bendectin (Blackmun, 2004). According to expert scientific literature however, Bendectin was not a risk to cause birth defects. Other parents of the handicapped children argued that the maternal drug had caused birth defects in their children listing scientific studies to prove their case (Green et al, 1999). Their studies supposedly tested animals with the drug and birth defects were a possible outcome, however the court found that this scientific information was not as reliable as the previous sources which said the drug was safe (Moenssens, 2004). The Court of Appeals agreed the new evidence provided by the parents did not meet the general acceptance of the court. The case of Frye vs. United States was cited as a reference. The case again reinforced and tested expert testimony and forensic evidence.

1989, The People vs. Castro:

In the People vs. Castro, the New York state Supreme Court charged Castro of murdering his neighbor and her daughter. The investigation took place in 1989 when DNA testing was becoming better known and more acceptable. A bloodstain was found

on Castro's watch after the murders (Raghaven, 2004). Investigators sent the watch to be tested. During the DNA examination, scientists at Cellmark Inc. concluded that the sample from the watch matched the DNA from the neighbor. The possibilities of it not being a match was about 1 in 100 million which was an estimate solely based on the Hispanic population (Raghaven, 2004).

The reason this case was a landmark case, and not just any DNA based case, was what both sides of the court did next. Both the prosecution and the defense agreed to meet to discuss the scientists DNA profiling steps. Both sides came to the unusual conclusion that the evidence in this particular case was not reliable (Weir, 1993). The outcome of this case was the establishment of the famous "three prong test" used frequently thereafter: 1) Is there a generally accepted scientific theory stating that DNA testing can be reliable, 2) Do techniques exist that can produce reliable DNA results, and 3) Did the testing lab perform these accepted DNA tests in this trial? For the Castro case, prongs 1 and 2 were met, but prong 3 (as performed by Cellmark) was not, so the DNA evidence was not allowed. The case proved to be the most rigorous testing of DNA evidence ever performed to that date, and resulted in the establishment of the FBI's "Technical Working Group on DNA Analysis Methods" (TWGDAM), to improve the standards and controls for DNA testing.

Conclusion

DNA evidence has become a strong useful tool in distinguishing guilty parties from innocent. Its biggest challenge to overcome in becoming an essential part of more

cases is reliability. Not that the testing itself is unreliable, the difficulty lies in proving to the court that the evidence is sound and free from being tarnished. Each case brought a new dimension to the acceptance of new technology in the method of DNA fingerprinting. The sample landmark cases mentioned in this chapter were crucial to the progression of the use of DNA testing, expert testimony and evidence gathering as a means of finding justice for all.

CHAPTER 4: SENSATIONAL DNA CASES

In the previous chapters we considered the main ways to run a DNA fingerprint, how to handle DNA evidence at a crime scene, and some of the landmark court cases that set precedents for accepting DNA evidence in the courtroom. Now we turn our attention to the court cases where the public is most likely to have first heard of DNA analysis. The following summarizations are of probably the most sensational cases involving the use of DNA fingerprinting. Many of these cases became famous because of the parties' social status. However, other cases involved crimes that became high profile because of the uniqueness of the case and the evidence contained in them. DNA analysis has had a dramatic effect on bringing people to trial especially in high profile crimes because it has made convictions more probable for prosecutors. Prior to the use of DNA fingerprinting, a conviction was only assured if witnesses were present, the accused confessed, or there was an extremely strong motive. The lack of some kind of undeniable physical evidence allowed many guilty parties to be set free, especially in these high profile cases. DNA analysis was a giant step forward for the judicial system in the conviction of criminals. Physical evidence can now corroborate the prosecution's claim of guilt, or help to set then free if found innocent. Since individuals can not alter their DNA, criminals convicted by their DNA are much more difficult to be disputed or to be ignored by the jury, although in some cases DNA evidence by itself is still not enough to convict.

1954 - State of Ohio vs. Sam H. Sheppard

Figure 4-1: Marilyn and Sam Sheppard (McGunagle, 2004)

Marilyn Sheppard was a loving mother and wife. She taught Sunday school at the local church as well as participated in other community events. Sam was a respectable doctor in Cleveland, where the two resided. Marilyn and Sam seemed to be the perfect couple, until Marilyn was found dead in her bedroom with 35 knife wounds in her body (Levy, 1996, pp. 67). This murder shocked and confused the community especially after hearing Dr. Sheppard's unbelievable story. Sheppard told police an intruder murdered his wife while he was asleep. When Sheppard awoke, he chased the culprit out the door and down to the beach where he struggled with the man. Sheppard claimed he somehow lost consciousness and the man escaped (Levy, 1996, pp. 68). When he finally awoke after the struggle, he realized the severity of his wife's attack and called a neighbor who then called the police. Investigators were skeptical of Sheppard's story from the beginning. There was no sign of a forced entry and no fingerprints of an intruder were found anywhere in the house. The only evidence that made Sheppard's story even somewhat possible was the severity of his many wounds, including a spinal cord and a neck injury. Shortly after the murder, stories of Shepard's affair with another woman, as well as other evidence surfaced and Sheppard was placed under arrest (Levy, 1996, pp. 71).

During the next few months following the arrest, other suspects surfaced and were investigated. Suspicion was even cast on Mr. and Mrs. Houk, the Sheppard's' neighbors who called the police. A second serious suspect was a man by the name of Richard Eberling. Eberling was a considered a strong suspect because he fit the description given to the police by Sheppard soon after his wife's murder (McGungle, 2004). Shepard could possibly have identified the assailant had he ever met Eberling, however Shepard had never met the window washers. Also, Eberling had been a suspect in numerous other cases involving similar violence. Perhaps the most damaging evidence against Eberling was that he was a regular window washer for the Sheppard's home and he knew of the unlocked basement door, which would explain the lack of a forced entry in the home. The possibility of other suspects led to reasonable doubt.

Figure 4-2: Eberling's mug shot in 1959 and a sketch of the intruder in 1954 (McGunagle, 2004)

Unfortunately, DNA fingerprinting was unknown at the time of the Sheppard murder. If the Sheppard murder had occurred nowadays, it would have been a clear cut case due to the blood samples of the perpetrator found throughout the house, as well as on a murder weapon imprint on a nearby pillow. Because the police had little knowledge of how to collect DNA evidence, much of it would be unusable since many people had been around the crime scene and contaminated the evidence before it could be gathered. The information about the evidence did not come to light until after Sheppard's first trial.

Although Sheppard was found guilty at his first trial, the conviction was overturned in 1966 at a second trial (McGungle, 2004).

In 1997 some of the original blood evidence in the Shepard case was tested using DNA fingerprinting. Because the police had little knowledge in 1954 of how to collect DNA evidence, much of it was unusable since many people had been around the crime scene and contaminated the evidence before it could be gathered (Lawyer, New DNA…1998). However, the testing was accurate enough to ascertain that some of the blood on a closet doorknob belonged to an individual other than Shepard and his wife. The evidence was not used to convict Eberling because the quality of the evidence was only good enough to exclude, not include. Dr. Sheppard's story was portrayed in the "The Fugitive", a television series and a Hollywood blockbuster. The publicity of the original case and the re-enactment of the story in the movies and television made this a high profile case.

Today investigators follow much stricter policies. All DNA samples are kept dry and at room temperature to prevent degradation in the DNA sample. Paper envelopes are used as well as tape instead of staples (McGungle, 2004). Virtually everything that can be done to prevent contamination is practiced. The result is that mysterious cases such as this one, where the most likely suspect is not guilty, can be solved quickly and the guilty parties arrested and convicted.

1995 - The O.J. Simpson Murder Trial

Another murder case where the husband was the leading suspect in his wife's murder was the O.J. Simpson trial. The O.J. Simpson murder trial is perhaps one of the most well known court case of all time, and is commonly referred to as the "Trial of the Century". Simpson was very much in the public eye ever since his professional football days. His case became so popular because even the average person felt that they knew him. His popularity increased the shock people felt when he was accused of the double homicide of his ex-wife Nicole Brown and her friend, Ronald Goldman. Simpson stood accused of breaking into their home on the night of June 12, 1994, and brutally stabbing them to death (Levy, 1996, pp. 157). Simpson was immediately a strong suspect in this case, and DNA proved to play as crucial a role. Blood samples were found at the home of Nicole Brown, O.J. Simpson's estate, as well as his white Ford Bronco (Levy, 1996, pp. 158). Blood stains are normally difficult to explain. The DNA testing on these stains hurt Simpson's case by showing that it was in fact the blood of the victims in his car and at his estate (Levy, 1996, pp. 158). Additionally, his blood was positively identified as being at the murder scene.

The solid DNA testing appeared to make this an open and shut case. However Simpson's lawyers realizing that they had very little evidence as a means of defense did the only thing they could do. They attacked the viability of the DNA testing and suggested possible corruption during the gathering of the evidence. The defense asked the jury to question everything from the DNA laboratory itself, to the persons who gathered and handled the samples prior to testing (Levy, 1996, pp. 159).

The first of a string of strong accusations provided by the defense came against detective Mark Fuhrman. Fuhrman was present at the crime scene and was potentially capable of tampering with the evidence (Levy, 1996, pp. 160). Simpson's lawyers believed they could prove that the detective had a vendetta against Simpson, as well as prove he was a racist who lied under oath. The defense further argued that a detective Vanmatter was a crooked cop as well, this was important because Vanmatter had access to the blood samples (Jones, 2004). Vanmatter was an easy target because he went to the Simpson estate without a warrant on the night of the murders (Levy, 1996, pp. 161). The detective insisted that he feared that there could be more victims and that had preference over getting a warrant. This infraction of the rules gave way to numerous accusations against the detective's character. Vanmatter was in charge of bringing Simpson's DNA blood samples to the lab for testing the day after the murder. One sample was in the detective's possession for a longer period than it should have been according to the defense team. There were also some samples that were not accounted for. The mishandling of the DNA samples was exactly what the defense was hoping for, because it allowed them to create alternative stories in Simpson's defense (Levy, 1996, pp. 162).

The next step in questioning the validity of the DNA results was to find fault with the lab and the evidence itself. The first of the DNA evidence against O.J. was drops of his blood on the walkway at Brown and Goldman's residence. Simpson's lawyers argued that first of all the new type of DNA testing was too easily contaminated to be admissible in court (Simpson Judge….1995). Typically forensics scientists use the RFLP technique to determine if a sample matches the DNA of the suspect, since that test is less sensitive to contamination. That test is a non-amplifying test, so DNA contamination remains a

minor portion of the final results. However on this case they used two types of PCR testing called the DQ alpha test, and the D1580 test (Levy, 1996, pp. 163). PCR testing can amplify contaminating DNA in a sample, so great care must be used with it. These PCR tests were new at that time, and the defense questioned the LAPD's competence in conducting such easily contaminated testing. The decision was made to use PCR tests because the technique is very sensitive, and the smallest sample can be used to determine results. The defense claimed the PCR testing was too sensitive and that there were many possibilities in which the sample could have been contaminated. The slightest mishap such as using the same tweezers twice when handling the samples could produce wrong results (Levy, 1996, pp. 170).

The DNA testing on all blood samples showed only the profiles of Nicole Brown, Ron Goldman, and OJ. If the defense's theory of another killer was correct, then why was there no second DNA of the real killers? The defense argued that the samples were so contaminated, that the test couldn't find another person's DNA. The defense also claimed the swatches containing the DNA's were stored in the sun for too much time, despite the fact that the samples still tested fine (Jones, 2004).

The defense made a bold move to stick with both of their defenses, the conspiracy and the contamination theories. Simpson explained blood stains in his home and Bronco on a cut that he received when reaching for his cell phone in the car, earlier in the day. Blood stains belonging to Brown and Goldman the defense claimed were planted by Fuhrman (Levy, 1996, pp. 183).

The prosecution had a more difficult time than the defense, because they have to prove that without a doubt the defendant is guilty. The defense on the other hand just has

to show other possibilities contrary to the accusations (Levy, 1996, pp. 185). Before the jury met to decide their verdict, the judge reiterated to the jurors that their role was to base their decision on the evidence, not any common sense or feelings they might have had as to the defendant's guilt. In the criminal trial, Simpson was found not guilty of the murder of Nicole Brown and Ron Goldman, however in a subsequent civil trial based only on the preponderance of the evidence he was found liable for their deaths (Jones, 2004).

This criminal case was important not just because of O.J. Simpson's popularity, but also because of the impact it had on future DNA court cases by spurring tighter controls on how DNA evidence is collected and handled. The Simpson trial is referred to often when dealing with PCR testing where the evidence collection techniques especially need to be controlled. It now frequent practice to purposefully contaminate a portion of a DNA sample to determine whether contamination if present affects that particular test (Levy, 1996, pp. 188).

1996 - Monica Lewinski Scandal

The Monica Lewinski scandal was part of the well known impeachment trial of former President Bill Clinton. This trial was important to DNA fingerprinting because it was highly publicized and its outcome would affect this country, as well as the world. Also this type of trial was uncommon; in fact no President had been impeached in over 130 years, since Andrew Johnson (Posner, 1999, pp. 7).

Monica Lewinski worked as a White House intern. During her time spent at the White House, Lewinski was accused of having sexual relations with the President on numerous occasions. The fact that he allegedly had an affair was not the main issue; the real issue was the fact that he stood accused of lying about his relationship with her under oath (Posner,1999, pp. 12). The world was informed of the Clinton investigations on January 21, 1998. Clinton was not officially charged until December 19th of the same year. The official charge for impeachment was perjury and obstruction of justice by the House of Representatives (Posner,1999, pp. 16).

Prior to the accusations, the President's aids were well aware of the President's behavior and tried to protect him by transferring Lewinski to a different job away from the White House and the President. The removal of Lewinski from the area did not end Clinton's problems however, because it came to light that Lewinski was not the only affair the President had. Paula Jones was the first to bring forth accusations against the President. Jones knew Clinton during his days as Governor of Arkansas (Posner, 1999, pp. 20). She accused him of having a sexual relationship with her. As the publicity grew and the Supreme Court allowed Jones to proceed with her lawsuit, Clinton told Lewinski they could not continue with their relationship anymore. He turned down her pleas to transfer her back to the White House fearing if her story became public, it would only add to the prosecutions case. Prior to the actual trial of Paula Jones' lawsuit, Clinton's fears came to light when Jones's lawyers released a list of witnesses to appear in court and on that list was Lewinski's name. Linda Tripp was a fellow employee of Lewinski at the White House. Lewinski had told her of the affair as a friend and looked to her for guidance. Tripp told the prosecution about Lewinski because she was bitter about not

advancing at her job. She attributed her stationary position to denying Clinton advances that he had made upon her (Posner, 1999, pp. 27).

DNA was a strong asset to the prosecution's accusations in the Lewinski case. Every person has heard of the infamous dress of Lewinski's that scientists found semen stains on, which was directly matched with the DNA of the President. Once the world learned of the DNA match, and the Tripp tapes, an explanation was due (Posner, 1999, pp. 29). Clinton denied having any kind of sexual or inappropriate behavior with Lewinski at any time. He denied the allegations both publicly and behind the scenes to his cabinet and closest friends. An independent counsel made Lewinski an offer to tell the truth. They gave her full immunity in order to get the real story. They talked Lewinski into it given all the proof against her. The Tripp tapes, testimonies of close friends, but most importantly the DNA on Lewinski's dress that matched the President's (Posner, 1999, pp. 31).

Clinton finally decided it was time to come clean, at least partly. He testified on closed-circuit television and admitted to having inappropriate sexual relations with Lewinski. He came clean just before the DNA testing was to be released to the public which would have proved him to be a liar. Clinton was a sly individual though (Posner, 1999, pp. 32). He still denied having lied due to the American people, given the nature of the questions asked to him and the court's definition of sexual inappropriacy.

In the midst of all the allegations Clinton launched missile attacks on Iraq, Afghanistan and Sudan. Most agree that it was done to distract the public from his ongoing case; however defense officials urged that this was not the case (McIntyre, 1998). The House of Representatives had two options left. They could go full charge at

the lesser crime of perjury, or try to prove that he was guilty of obstruction of justice (Posner, 1999, pp. 37). Perjury was just about a done deal but the House wanted to get Clinton on harsher charges, even perjury was fairly easy for them to prove. In the end their efforts went nowhere and Clinton was acquitted. DNA was very influential in the outcome of this case because it was the most damaging piece of evidence against the President. Without it, it would be his word against everyone else's. It was the only proof that the prosecution had to prove his guilt and force him to admit to the accusations (Posner, 1999, pp. 56).

1965 - Albert Desalvo (The Boston Strangler)

The Albert Desalvo (The Boston Strangler) case has recently undergone a bizarre twist of circumstances. The first event of this extremely famous series of related cases began on September 29th, 1964 at a gas station in Andover, Massachusetts (Bailey, 1971, pp. 171). An unidentified man, wearing a trench coat, stabbed and then shot the station attendant. The only witnesses to the attack were a woman and her daughter who were parked in a nearby car. The man walked over and fired two shots into the car and then fled the scene. The two women were unharmed; however, they could not give much information. Police did not have any motive for the attack since no money was taken. The police had no other leads to pursue (Bailey, 1971, pp. 173).

George Nassar was an ex-convict who was trying to keep out of trouble. When Nassar was a young man, he had killed a grocer in a robbery that had gone astray. One day while Nassar was walking down the street, a local police officer saw a vague

resemblance between Nassar and the rough sketch produced by the two witnesses at the gas station attack (Bailey, 1971, pp. 174). The two witnesses later positively identified him as the killer and Nassar was charged with first degree murder. A famous lawyer, F. Lee Bailey, made the decision to represent Nassar at his murder trial. During one of their lawyer/client conversations, Nasser confided in Bailey that he had been regularly talking to a man who was being held in a mental institute in the town of Bridgewater, Mass (Bailey, 1971, pp. 175). Nasser claimed the man he was in contact with, Albert DeSalvo, who claimed to be the notorious "Boston Strangler". Bailey was hesitant about believing Nassar but decided to follow up on the claims anyway.

DeSalvo suffered many hardships in his younger years, running away from home many times. He regularly watched his father beat his mother. When he was very young, his father showed him how to shoplift (Bailey, 1971, pp. 176). Then when he was twelve years old he was arrested for helping attack a paperboy for his money. Additionally, he regularly watched his father have sexual relations with prostitutes. DeSalvo had sexual relations himself with a 35 year old woman when he was only 15 (Bailey, 1971, pp., 176). He eventually joined the army, got married, and avidly pursued boxing. It appeared that perhaps he had turned his life around. But that was not to be the case and in the late 50's he faced breaking and entering charges. DeSalvo also ran a scam of helping women pursue a model career. He would approach women at their homes and would convince them that he was going to help them become a model. After gaining their confidence, he told them he needed to get their measurements. That's when he would molest them. He was nicknamed the "Measuring Man". A Boston University co-ed

eventually identified him which resulted in a year in jail for DeSalvo (Bailey, 1971, pp. 177).

He later faced similar charges as the "Green Man". The "Green Man" had a similar scam, the only twist was he usually wore a green uniform. As witnesses started to come forward identifying him, he admitted to nearly 400 break and entering in the greater Cambridge area, as well as molesting 300 women in the New England area (Bardsley, 2004). However he denied any involvement in the famous Boston strangling's. After DeSalvo's admission of guilt for the "green man" molestations, he was then sent to Bridgewater State Hospital where his mental state was tested. During the testing, a psychologist diagnosed DeSalvo as having a "sociopathic personality disorder marked by sexual deviation, with prominent schizoid features and depressive trends". In short DeSalvo was severely unstable (Bailey, 1971, pp. 179).

Given DeSalvo's background and this psychological diagnosis detectives went to Bridgewater to get DeSalvo's palm prints, in suspicion of the famous 11 stranglings between June 1962 and January 1964. There was a flaw in their suspicions because during the first six stranglings DeSalvo was in prison, although there was a green suit left at one of the scenes (Bardsley, 2004). So an important question is whether there was more than one strangler, Nasser for the first 6 stranglings, and DeSalvo for the rest? Also there was no sign of breaking and entering at any of the murders, which would have helped implicate DeSalvo given his record as a con artist. DeSalvo was ready to confess on numerous occasions. One time he was ready to tell a detective all about it but the detective decided not to question him since his lawyer was not present (Bailey, 1971, pp. 180).

The first official victim was an older woman named Anna Slesers. Slesers was a semi-recent divorcee who had moved to a third floor apartment in a low income building. She was found by her son naked and strangled by a cord from her bathrobe. Anna was involved with the community and an avid church goer. She also was partly reclusive though and most of her free time was spent by herself. The Slesers murder was followed a few weeks later by the strangling of a sixty eight year old woman named Nina Nichols (Bardsley, 2004). Nichols was found in a similar fashion, also she had appeared to have been burglarized like Slesars. It would appear as though there was some sort of pattern. If the murders were linked it would seem as though older women living alone were at the greatest threat. However the next victim a few months later, was a twenty-one year old college student, Sophie Clark. Of the eleven official victims, six of their ages ranged from 19 to 23, the rest from 55 to 75 (Bardsley, 2004). These extreme ranges showed little to no consistency and only added to the confusion. These inconsistencies added to the disturbing nature of these crimes, because no woman was the same, and the victims had no similar age or lifestyle.

After a couple meetings with DeSalvo, Bailey was convinced he was talking to the notorious strangler. DeSalvo told Bailey that he wanted to write his story in order to get money for his family. Bailey got in contact with detectives who were investigating and had knowledge of the case. The real question was "is DeSalvo really the killer or just a mentally challenged man looking for fame or money." It was not until after the second meeting that, DeSalvo admitted to the 11 killings plus two others the police were unaware of (Bailey, 1971, pp. 202). He went over the murders in astonishing detail and at long last the detectives were also convinced they were dealing with the real killer.

DeSalvo was asked to take a polygraph test which he readily consented to. He first however had to convince the doctors that he was capable of taking such a test. DeSalvo told Bailey he could easily convince the psychologist of his competency and he did. The polygraph was not done right away though because no such tests are admissible in court, so there was no rush (Bailey, 1971, pp. 204).

By this time a strangler bureau was formed and started taking over the case. It was the head of this bureau that had taken the palm print of DeSalvo earlier. The bureau claimed to be zeroing in on him from the palm print and other unknown tactics. The head of the bureau decided to try hypnosis on DeSalvo. The hypnotist was very intrigued by DeSalvo's mental state (Bailey, 1971, pp. 208). DeSalvo had a daughter named Judy who was born with a leg defect. She had to wear a cast and have daily physical therapy which was performed by DeSalvo. His victims were tied using the same knot as used on the cast. Also, after he killed them, he would rub his victims' legs in a similar way as he did with his daughter. During the hypnosis sessions DeSalvo had blocked out the murders. He would describe everything to the point of the murder and then he would talk about his exit and the rubbing. It was obvious he had some deep rooted issues from his past (Bardsley, 2004).

The only two witnesses were from recent strangulations. They came to the station to see if they recognized either DeSalvo or Nassar. Neither witness recognized DeSalvo but both said Nassar looked familiar. However DeSalvo recognized them and stated where he knew them from. This was good for Nassar because it had started to look like Nassar had perhaps been the real killer and used DeSalvo as a decoy. An extensive interrogation was commenced and nearly 50 hours was recorded of DeSalvo going over

details with astonishing accuracy. (Bailey, 1971, pp. 206) Meanwhile Nassar was put on death row despite Bailey's best efforts. The case was getting very complex. Detectives wanted to research DeSalvo and avoid the death penalty given his mental state, however the public was looking for some sort of justice. Also DeSalvo could not readily confess because his confession would be inadmissible. A final court date was set to determine once and for all if DeSalvo was competent enough to stand trial. If so it was decided he would be tried as the "Green Man", instead of the strangler. (Bardsley, 2004). This charge would give him, if convicted, a life imprisonment charge without the possibility of parole, instead of the strangler case which would be harder to prove, and could most likely result in DeSalvo's execution. After a lengthy period of testing and hearings it was decided that DeSalvo was competent to be charged (Bailey, 1971, pp. 208).

Bailey created an ingenious plan to help DeSalvo avoid conviction in the "Green Man" trial. Bailey pleaded insanity for his client using the stranglings as proof. Despite Bailey's best efforts DeSalvo was convicted on all counts. DeSalvo was in despair now knowing he would not be able to get the mental help he had wanted. DeSalvo was eventually sent to a jail after a short time at the mental institution at Bridgewater. In prison, he shared the same jail as Nassar who had also been convicted on all counts at his retrial, of the murder case of the gas station clerk. One night, however, DeSalvo and two others escaped from prison (Bailey, 1971, pp. 209). The city was terrified and reports came in all around the country. The whole time he was in his home town of Boston. He was caught unharmed and brought back to jail where he resided without the mental psychiatry that could have helped to explain what caused him to commit these terrible crimes. Knowing why could possibly give insight to prevent this from happening again.

DeSalvo was murdered in 1973 by a fellow inmate while still incarcerated (Bailey, 1971, pp. 211).

This case initially took place far before DNA fingerprinting was developed. However in 2001, the DNA evidence from the exhumed body of Mary Sullivan (the last of the serial victims) was compared to Albert DeSalvo's surviving son (Bardsley, 2004). Surprisingly the two DNA's did not match. This proves that DeSalvo did not rape the last victim. But this raises more questions than it answers. Maybe DeSalvo committed the earlier murders, but not Sullivan's? Maybe DeSalvo committed none of the murders. Casey Sherman was a nephew of Sullivan who believed DeSalvo was not the real killer. The police had a suspect that was abandoned when DeSalvo confessed. Sherman believed the original suspect was the real murderer and urged police to further investigate (Bardsley, 2004). Nothing has been done though since. Only by exhuming some of the earlier bodies can these questions ever be answered (Bailey, 1971, pp. 217).

CHAPTER 5: DNA DATABASES

The world's first *national* criminal intelligence DNA database was launched in April 1995 in the United Kingdom ("The National…., 2004). Run by the Home Office Forensic Science Service, DNA profiles are sent to the custodian, who loads the profiles into the database. The computer system can then check for a match overnight, and in the morning, print out reports based on "match criteria" ("Mouth Swab …., 2004). New Zealand, China, and Australia are just a few of the dozens of countries which have established DNA databases to identify and convict (or acquit) suspects accused of committing crimes ("Global Survey…., 1999).

In the United States, the era of national DNA databases was ushered in when in 1998 the FBI went online with CODIS – the COmbined DNA Indexing System – a system for integrating local, state and federal law enforcement agencies with the tools necessary to compare and exchange DNA samples electronically. CODIS was first tested among 14 state and local laboratories. The DNA Identification Act of 1994 (Public Law 103 322) gave the FBI authority to establish a national DNA index for law enforcement purposes. In October 1998 the FBI's National DNA Index System (NDIS) became operational (The FBI's…, 2000). In the year 2004, the FBI boasted of having the CODIS system working at 175 crime laboratories in all 50 states, Puerto Rico, and the FBI's and the U.S. Army's crime labs, containing over 1.7 million DNA profiles.

CODIS works as a distributed network, where many computers are interconnected and act almost as though they are one. Processing is done by local computers, and the processors can be dynamically assigned to tasks as they become available. What this means is that once a local forensic laboratory creates a DNA profile, the profile gets

converted into a series of digits which represent the molecular sequences at the 13 currently accepted forensic DNA loci; these numbers then get loaded into the lab's computerized database, where it will stay. Then whenever anyone anywhere with a crime scene sample, who has access to CODIS, does a search, they will actually be searching the mini-databases stored on all the local crime labs' computers. The FBI supplies necessary software and training to implement CODIS in state and local labs performing DNA analysis. Though designed as a national database, there are actually three tiers to its inner-workings: local, state, and federal – NDIS, which is the national level, SDIS, which is the state level, and LDIS, which is the local level. Data is collected and stored at the local level. That information then flows up to the statewide and finally the national level (See Figure 5-1). The FBI claims that this method allows for local agencies to operate their databases according to their specific legislative or legal requirements ("The FBI's…., 2000).

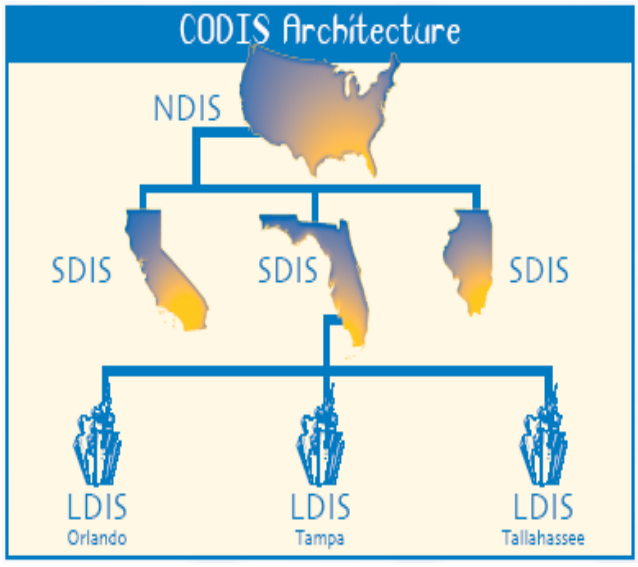

Figure 5-1: "The FBI's Combined DNA Index System Program", 2000, FBI, US Department of Justice

How DNA Databases Solve Crimes

Databases help solve cold cases – those cases where there is no suspect, but there is DNA left at the crime scene. Does that crime scene DNA match a previously convicted felon whose DNA is already stored in a database? Stories abound about how a difficult crime was solved easily with the help of CODIS. For instance, in 2000, an unidentified woman's body was found on an off ramp along an interstate in Des Moines,

IA. The Iowa Department of Public Safety sent biological evidence left at the crime scene to the FBI Laboratory for DNA analysis. The FBI Lab analyzed the evidence, and developed a DNA profile of the perpetrator. The profile was uploaded to CODIS, where NDIS matched it to a Florida offender. Another success story, also from 2000, tells how the St. Louis Police Dept. had their first cold forensic hit using RFLP technology. The hit involved two 1996 cases where young girls were abducted from bus stops and raped. In January 2000, CODIS matched the reanalyzed 1996 case hit to a 1999 rape case ("CODIS Success…, 1998). After the hit, police were able to identify the suspect as the perpetrator of two other rapes.

Or take the case of Mark A. Daigle. Sarasota police allege that a young woman was brutally attacked when Mr. Daigle entered the victim's apartment while she slept. Police were able to make a DNA profile from semen recovered at the crime scene. This profile was compared against convicted offender DNA samples in the state of Florida's criminal database. When the profile did not match any of the records in the database, authorities forwarded the DNA profile to other states participating in the CODIS program. Virginia officials reported a match with a sample taken from Mark Daigle when he was incarcerated in a Virginia prison. Following this lead, the Sarasota police compared a bloody print left at the rape scene with Daigle's fingerprint records. Both sets of prints matched, and Daigle was arrested on November 13, 1997 ("CODIS Success …, 1998).

CODIS has two separate, yet equally important facets for solving crimes: the forensic index, and the offender index. The offender index is able to identify suspects by matching DNA found at a crime scene to the DNA profiles stored in its database. This

comparison from person-to-person type of index is particularly useful in linking criminals to crime scenes across the state, or even the country. But what happens when the DNA found at a crime scene doesn't match any DNA profile already in the database? When the offender is unknown, authorities can use the forensic index to compare crime scene-to-crime scene. This useful process can establish that DNA profiles obtained from separate crime scenes are the same, or unique. While this doesn't give the police a definite suspect to look at, it can lead authorities to uncover serial crimes. Comparing clues from these related – previously unknown – crime scenes may lead to a possible hit.

DNA Collection for Databases

One of the pioneers of DNA databases in the United States was the state of Virginia, which began theirs in 1989 (Puri, 2001). Originally, samples were included from felons convicted of only certain types of violent crime, and from sex offenders. In time, however, the legislature authorized the state to include all newly convicted felons. This expansion was applied retroactively to current felons, who were required to submit samples upon release. After the Fourth Circuit of the United States Court of Appeals upheld the statutes as being constitutional, according to *Jones v. Murray* in 1992 (F.2d 302, 306-07), the legislature further expanded the database in 1996. The new database also included certain juvenile offenders over the age of fourteen.

Today all fifty states have enacted some form of a criminal DNA database (Smith, 2002). Though the states unanimously collect samples from people convicted of certain sex offenses, individually they differ on what other crimes are requisite for the collection of DNA. Some states require samples from all felons both violent and non-violent. Other states require collection from people convicted of various classes of misdemeanors.

In addition, a few states even require collection of blood from those arrested, but prior to conviction. Moreover, an increasing number of states have required inclusion of juvenile offenders as well (Puri, 2001).

In a Boston Globe article dated 9/30/2003, Brendan McCarthy writes of Massachusetts:

> *"The state's current DNA database, which was established in 1998, requires samples from people convicted of one or more of 33 violent offenses, such as murder, rape, and kidnapping. Proposed legislation would expand the DNA database to include samples from any convicted felon, enlarging the database of 20,000 samples to nearly 90,000, according to Senator Cheryl A. Jacques, lead sponsor of the bill…" (McCarthy, 2003).*

On November 12, 2003, Gov. Mitt Romney, R-Massachusetts, signed this bill into law as an act requiring that "Any person who is convicted of an offense that is punishable by imprisonment in the state prison, and any person adjudicated a youthful offender by reason of an offense that would be punishable by imprisonment in the state prison if committed by an adult shall, within 1 year of such conviction or adjudication, submit a DNA sample…" (Mass General Laws, 2003). Therefore, if you are convicted of committing an imprison-able crime in Massachusetts, no matter how old you are, and this crime carries a jail sentence, your DNA profile is going into the Massachusetts DNA database. This same law went further and instructed people already incarcerated, and persons on parole or probation to submit a DNA sample to the department within 1 year after the effective date of this act. Currently, Massachusetts does not collect the DNA of suspects or arrestees.

Only a few states allow the collection of DNA from persons arrested, but not yet convicted of a crime (Herkenham, 2002). But the differences between the state's individual policies do not stop at the type of offenses for which authorities may collect

DNA samples. The states also specify what is allowed by law regarding the uses of the databases themselves. Though most states allow the databases to be used for any kind of criminal investigations, some states restrict which types of criminal investigations are allowed. For example, the state of Mississippi only allows database analysis for sex crimes. On the other hand, some states allow disclosure of DNA samples with a court order; it is reasonable to think that these samples could be used in civil cases, such as paternity suits. With all these differences from one state to the next – from whose DNA is collected, for which crimes, to how different law enforcement agencies can use the database as an investigative tool – it's no wonder that CODIS operates on three levels.

Statistics and DNA Databases

In the courtroom, prosecutors would like to report to juries that so-and-so's DNA is unique, and that there is no way any other human being could possibly have left that sample at the crime scene, therefore so-and-so must have committed the crime. The results of a DNA profiling with current technology will **never** give results that claim that a sample could only have come from one particular person. A non-match or exclusion of two DNA samples is far easier to prove than inclusion. Recall from Chapter 1 that the DNA in our chromosomes has 3,000,000,000 base pairs (or 3000 mega-bases). A single gene is represented by a few thousand bases. With between 30,000 and 40,000 genes, this means that around 150 mega-bases carry useful information. In other words, nearly 98% of the DNA in your chromosomes doesn't encode proteins, and carries no useful medical information ("The Human Genome Project", 2004). Therefore, when we analyze someone's DNA forensically, we don't actually sequence it from beginning to end. That

would take an enormous amount of time, and yield relatively little information. Instead, we analyze specific loci (locations) on the DNA strand to be more efficient and productive.

The obvious downside to not checking every single locus is that, theoretically, two people could match the same DNA profile. A famous case from England circa 1999 illustrates this point; one man was arrested for burglary when DNA found at the crime scene matched his DNA at the 6 loci analyzed, the standard number used for testing at that time (Moenssens, 2000). The fact that he had advanced Parkinson's disease, and could not even drive the 200 miles from his house to the site of the burglary didn't matter to police. It was not until his counselor demanded retesting at 10 loci that the error was discovered: the additional 4 loci didn't match. Thus, by checking only a subset of loci, the possibility always exists that two people "have the same DNA". Since the reality is that no two people have the same DNA sequence (with the exception of identical twins), unique identification with DNA typing is possible, with the provision that enough sites of potential variation are examined. But a match between two DNA patterns using 3-5 loci can be considered strong preliminary evidence that the two samples came from the same source. For criminal investigations, the FBI currently requires 13 specific loci for its CODIS database, while England now uses a 10-loci test.

How many locations should we check? How many will be enough to include or exclude a suspect? Each locus has a statistical frequency that we can assign to it. This frequency represents the probability that a given DNA profile will contain that particular locus in a given population. By multiplying the percentages together, investigators can determine at what frequency a particular combination of types is expected to occur in the

population. The more loci analyzed, the more we can multiply each of their individual probabilities together to increase the overall probability. But we need to calculate the frequency of each locus in the general population. Once we understand that, we can multiply the frequency of locus-1 by the frequency of locus-2, etc. to obtain the overall chance of the match occurring randomly. DNA databases, like CODIS, allow us to test a greater number of people's DNA for precise allele frequencies. A frequency based on only a few samples is less accurate than one based on thousands of samples. The larger the database of samples, the more accurate the allele frequency probabilities get assigned. The more accurate the probability of a match, the more likely the data will get accepted into the courtroom. It is here that CODIS, and similar databases around the world, help to ensure that the right person or persons are brought to justice.

Therefore, proper testimony to juries relies on the principles of *inclusion*, or *exclusion*. When a single locus is present in an evidence sample, but does not appear in a suspect's sample, we can safely exclude that person. If we "exclude" a suspect, then that person did not contribute the crime scene DNA sample in question. To eliminate a suspect, all you need is for a mismatch at one single locus. But if we fail to exclude, meaning that all loci tested are present in both the evidence and the suspect's sample, we cannot simply say there is a "match". Since we didn't analyze the entire genome, all we can truthfully say is that it may be likely the suspect did contribute the sample in question. In other words, we would have to "include" the suspect as one of possibly many people in a select group who could have left such a sample. Bruce Weir explains, "If a DNA profile contained in evidence is known to be that of the perpetrator of a crime, and a person found to have that profile is arrested and prosecuted, then the numerical

values given in court are derived under the assumption that the defendant is not the perpetrator. In other words, what is the probability that the defendant would have such a profile given that the perpetrator has the same profile and these are different people? This number is called the match probability" (Weir, 2001).

Once a person's DNA profile is known, reporting inclusion to judges and juries requires a valid scientific method for estimating the match probability. This typically takes the form of a population database in which each locus and genotype used in the forensic analysis has a known frequency estimate. With this reference, it becomes easier to weigh the significance of a DNA match between a defendant and a forensic sample. To say that two patterns match completely would be misleading and inaccurate. Truthful testimony relies on a scientifically valid estimate of the frequency with which such matches might occur by chance.

To illustrate the concept of specifying a random match probability, refer to Table 5-2, developed by Bob Blackett, a DNA Analyst, as part of his proficiency testing (Goss et al, 1996). For each genetic locus, the table shows the expected frequency of the noted genotype in a representative population sample. For example, at the genetic locus known as D18S51, and given a genotype of 12, 13, the sample chart reveals that this genotype is

Locus	**D3S1358**	**vWA**	**FGA**	**D8S1179**	**D21S11**	**D18S51**	**D5S818**
Genotype	15, 18	16, 16	19, 24	12, 13	29, 31	12, 13	11, 13
Frequency	8.2%	4.4%	1.7%	9.9%	2.3%	4.3%	13%
Locus	**D13S317**	**D7S820**	**D16S539**	**THO1**	**TPOX**	**CSF1PO**	**AMEL**
Genotype	11, 11	10, 10	11, 11	9, 9.3	8, 8	11, 11	X Y
Frequency	1.2%	6.3%	9.5%	9.6%	3.52%	7.2%	(Male)

Table 5-1: Sample DNA Profile for the 13 Core CODIS Loci and AMEL (Goss et al, 1996).

shared by about 4.3% of the population. By combining the frequency information for all 13 CODIS loci, we can calculate the frequency of this profile to be 1 in 7.7 quadrillion (1 in 7.7 times 10 to the 15th power). Thus, although we can never say two DNA samples are identical with absolute mathematical certainty, we can assign a likelihood of such a match occurring on a random basis, and let the jury use their common sense to determine whether the suspect's DNA likely matches the crime scene sample.

Database Ethics

With the discriminating power of DNA databases: to facilitate the ability to solve cold cases, to strengthen our statistical models of population frequencies, and to aid law enforcement in linking crime scenes and tracking down criminals, many authorities view DNA databases as an important tool in the fight against crime. Some would argue that society and government should do all they can to implement, support, and expand databases. Many government agencies are trying to pass laws requiring all citizens to contribute a DNA sample. But the average person still has reservations about the routine harvesting of DNA from ordinary citizens to strengthen existing databases. Until greater public debate and education has come to pass, misconceptions that exist will only fuel fears of the damage such a proposal would leave in its wake. Some recent opinions on the subject were posted to the Cosmic Log, an internet discussion board:

> ***Randy, Port Angeles, Wash****.: "I would never hand over my DNA to any government or private data bank. I am very suspicious of any group that wants to track people. In the USA we are not required to carry ID of any kind, and I believe that any national ID or DNA databank is dangerous."*
>
> ***Glenn****: "Genetic fingerprinting for everyone would be corrupt. Insurance companies would not cover people because they may be prone to an illness. Believe me, this information would be sold and used to make money out of us."*

***Robert**: "I have many privacy concerns with requiring a DNA profile for everyone. We have long been protected against unreasonable search and seizure. Requiring an individual to supply a DNA sample to police or other governmental authority without probable cause or reasonable suspicion is very troublesome.*

"It would be relatively easy to leave someone else's DNA at a crime scene to divert police attention away from the real perpetrator and frame an innocent person. If DNA evidence couldn't convict O.J., can it be used to bring justice to anyone?

***Barrie, Los Angeles**: "I can't even imagine the privacy and security issues this would generate. DNA is filled with so many indicators of potential illness, etc., that I can foresee a great deal of misuse and abuse of this database. There would have to be stringent controls and absolute privacy, and even then, just because your DNA is present at a crime site doesn't mean you yourself were present at the time of the crime."*

***Lori Hines, Michigan City, Ind.:** "I was excited to see this headline! I have often thought that DNA fingerprint records should be as mandatory as immunizations and Social Security numbers are, and perhaps could be procured by local health departments. At the very least, everyone arrested should have a DNA sample obtained and recorded."*

(Boyle, 2003)

As one can infer from these comments, the subject of DNA databases gives way to heated ethical debates. Many individuals and organizations rail loudly against mandatory submission to data banks. Often, the first question asked is "Whose DNA will we include in the data banks?" Several answers come to mind, each of which branches out into equally divisive arguments. The obvious first proposal is to store just the profiles of convicts. But which type: sex offenders only, violent criminals, certain criminals, or all crimes; what about juvenile offenders? Popular opinion suggests that certain types of criminals are more likely to suffer a relapse. When state databases were first developed, sex crimes spurred the usual impetus. The high probability of a repeat offense among sexual predators was often cited as a reason to collect these particular criminals' DNA for archives, "for the common good of the people". But according to the Bureau

of Justice Statistics, repeat offenders are convicted in higher percentages in other criminal groups such as violent felons. Furthermore, recent police work shows that a higher percentage of crimes solved using DNA comes not from rape, but rather from burglaries. The play-it-safe approach then is to sample everyone convicted of a crime? The argument here is that an individual's "right to privacy" is partially given up (to donate a blood sample) when he or she violates someone else's rights (as when committing a crime).

Collecting samples from criminal population groups, while laudable from the perspective of detective work, is often blasted as being racially biased. Since current studies hold that minorities are disproportionately represented in correctional institutions (Bonczar and Beck, 1997), the statistical models that would develop from this subpopulation to interpret future DNA typing results will also be skewed by this racial factor. Because genetic traits are correlated owing to population substructure – the alleles having different frequencies in different population groups – an argument could be made that profiling only convicts, or even all arrestees, ignores a large percentage of the population, and therefore produces inaccurate statistics.

The next logical choice then would be to either type everyone, or type on a random basis. Under current laws, every state is already required to draw blood samples from newborns to screen for potentially treatable genetic conditions (Rosen, 2004). This same blood sample can then be used to develop a genetic profile of the infant which would be added to the national data bank. But critics warn that sampling the entire population, as has been done in some countries, will turn us into a nation of suspects. The ultimate fate and potential uses of these samples are uncertain. Function creep, as

defined by Barry Steinhart of the American Civil Liberties Union, seems to be a matter of human nature. "In the 1930's promises were made that Social Security numbers would only be used as an aid for the new retirement program, but over the past 60 years they have gradually become the universal identifier that their creators claimed they would not be. Similarly, census records created for general statistical purposes were used during World War II to round up innocent Japanese Americans and to place them in internment camps." (Steinhart, 2003).

The government does have a history of breeching public trust. Coupling past failures with the potential for abuse, it's no wonder many people voice skepticism. That the government could sell this genetic information for profit is not exactly a far-fetched scenario, either. A similar event that occurred in Iceland should serve as a warning to all countries. In 1998, Iceland passed legislation creating a national database combining the health records with the genetic information of every citizen of that country. Access to this database was sold to deCODE, a private biomedical company. On January 1, 2000, deCODE announced that it had almost completed "The Book of Icelanders," an extensive genealogical database of all Icelandic citizens, past and present, and was planning to publish it on the internet (Hloden, 2000).

Eugenics, also known as genetic discrimination, is nothing new to this country. For many years it was commonplace to forcibly sterilize "mental defectives" who were held in state institutions (Buck v Bell, 1927). And as far as the private sector is concerned, the Council for Responsible Genetics, a nonprofit advocacy group based in Cambridge, Mass. has documented hundreds of cases in which healthy people have been

denied insurance or a job based on genetic "predictions" (Council for Responsible Genetics, 2001).

But do we really have to fear the release of medical information obtained through a DNA sample? Can they really find out everything about me, and my family tree? There is a huge difference between merely depositing information on the 13 core CODIS loci for criminal investigation purposes, versus depositing your entire genetic sequence that would contain medical information. In his testimony to Congress, Dwight Adams, Deputy Assistant Director, Forensic Analysis Branch, Federal Bureau of Investigation, Washington, DC, remarked that "records in the National database contain the following information only: an agency identifier for the agency submitting the DNA profile; the specimen identification number; the DNA profile [of the 13 core loci]; and the name of the DNA personnel associated with the DNA analysis. It is also important to note that the DNA profiles generated according to national standards do not reveal information relating to a medical condition or disease." And if the original DNA sample is destroyed after the 13 core loci are obtained, there is no chance of getting any medical information. "The Short Tandem Repeat (STR) core loci selected for use in CODIS were specifically selected as law enforcement identification markers because they were not directly linked to any genetic code for a medical condition." (Adams, 2000). Because the STRs are from non-coding regions of DNA, forensic scientists cannot glean genetic information about traits or medical conditions. CODIS, in fact, stores information as a sequence of numbers. The numbers have no meaning except as a representation of molecular sequences at the 13 loci, not linked in any way to an individual's personal traits or propensities.

Not everyone is convinced by the reassurance that current practices do not reveal personally identifiable information. Some are worried that advances in science and technology will eventually lead to new discoveries that could reveal information about a person from these previously non-coding DNA segments. Giving credence to such misgivings, a team at Harvard Medical School reported finding a "Junk DNA" gene that regulates the activity of nearby genes, in June 2004. "In a region of DNA long considered a genetic wasteland, HMS researchers have discovered a new class of gene." (Junk DNA…, 2004). That the 13 core loci could someday provide us with insights into our genetic makeup is, at the very least, unnerving, although it is unlikely that those 13 small loci would themselves be able to tell us anything useful medically just because junk DNA elsewhere in the genome was found to help regulate genes, and it would be impossible to determine an individual's entire medical predisposition from the 13 core loci.

We are well aware from news reports that databases offer hope in solving tough crimes. Advocates also claim that including everyone's DNA in a national database will be a deterrent to crime. Additionally, it will give us a tool to aid in the identification of bodily remains in the event of another terrorist attack, such as the 9-11 tragedies. But opponents counter with cost and backlog. The Advancing Justice Through DNA Technology Act of 2003 proposed to provide over $1 billion in funding and assistance "over the next five years" (Hatch, 2003). Included in this bill is a provision to eliminate the ***current*** backlog of over 300,000 rape kits and other crime scene evidence. With costs like that and the already overwhelmed testing laboratories, the cry is heard, "How can we afford to type everyone, and where will we store all the samples taken?"

Privacy and DNA Databases

Perhaps one of the most divisive and explosive debates comes from differing opinions about the right to privacy. Individual rights activists often cloak themselves in the veil of the fourth amendment: "The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated; and no Warrants shall issue but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized" (4th Amendment to the United States Constitution). This clause is often a springboard into the issues of privacy, but one for which no clear-cut direction can be mapped.

The first challenge to overcome is one's own definition of what constitutes a search. While we may all agree that drawing blood with a needle is clearly a seizure for the express purposes of a search, that distinction becomes blurry when we consider other methods for obtaining a DNA sample, such as using buccal swabs. In *Palmer v. State*, 679 N.E.2d 887, 891 (Ind. 1997), the Indiana Supreme Court reasoned that the warrant-less acquisition of a defendant's fingerprints during his trial did not constitute a seizure forbidden by the Fourth Amendment because "fingerprints are an identifying factor readily available to the world at large." But Mr. Steinhart, of the ACLU, is adamant that DNA profiles are not the same thing as fingerprints. He argues that fingerprints are a strictly physical form of identification. And while DNA fingerprinting is indeed a method of identification, its future potential for revelation is not clear. Advances in the sciences could lead to new understandings about individuals through their genetic makeup. Although this is true, and scientists almost every day are discovering new

mutations that lead to specific medical predispositions, an analysis of the 13 core loci is not an examination of an individual's entire genome. Only a complete genome-sequencing would uncover all their medical predispositions, and even then only after years of research to map all mutations to predispositions.

Proponents of databanks question just how unreasonable and invasive taking a DNA sample is. The answer seems to lie in "compelling public interest". Just as mandatory drug testing of everyone is not justified because there is no compelling public interest, there are those who argue that DNA testing all people is not justified. But, when *is* there a compelling public interest, and, in these cases, which if any rights are violated? Besides, the general standard for probable cause rests on the crux of "individualized suspicion" where this is said to draw the line between reasonable and unreasonable searches. However, the courts have repeatedly upheld searches lacking individualized suspicion where there has been a "special need exception" or a "public safety exception" to the Fourth Amendment.

Other privacy issues become murky as well when we consider how many potential sources of DNA come from one person. Are the police invading one's privacy when they pull a drinking cup out of the trash and analyze the saliva? If I trip on the sidewalk and scrape my hands, do I have the exclusive right to retrieve any lost blood? Once a person is defined as suspect through a legal process, his or her rights become diminished. Suspects' homes, cars and persons may be legally searched. They may be brought to a police station for questioning, and even arrested and held in prison, or their passports may be suspended; these actions depending on the individual states relevant statutes. Above all, they may be fingerprinted, regardless of whether they consent or not.

None of these measures can be legally taken against non-suspect people (many suspects get fingerprinted, and later found out to be innocent, but their fingerprints still get taken since they are a suspect for a good reason) (Etziomi, 2003). So to the author of this chapter, the right to privacy for non-suspect individuals outweighs the benefit to society of taking their DNA fingerprint (so they should not be required to provide a DNA sample). However, the right to privacy for suspect individuals does not outweigh the benefit to society (and they should be compelled to provide a sample).

Safeguards

While debate continues, and policy takes shape through political and philosophical discourse, it seems that current trends indicate we will follow in the footsteps of countries like England, and the United States will eventually implement a national DNA database comprised of all of its citizens. Even though we are moving through sparsely charted waters, things can be done to ensure that we proceed with caution and prevent recklessness. To allay the public's fears, and to promote safe, trustworthy management of any such national DNA database, the government should at the very least take steps to address these controversial areas: eugenics, privacy, and security.

Legislation should be drafted keeping DNA samples private, and requiring the original DNA sample to be destroyed so that future breakthroughs prevent any expansion of the original 13 core loci in the database to include medical information in addition to the forensic information. Current state and federal laws make no provisions for destroying the biological samples once the genetic profile has been made and entered into the databank. Immediately destroying the sample would ease tensions over protecting

genetic privacy. It is easy to say that the samples will never be used for anything besides catching criminals, but history teaches those who would learn that at some point temptation may lead to improper use. Since the scientific community has settled on a uniform set of DNA locations to be tested and a common methodology for this testing, what justification is there for retaining biological samples? CODIS employs this scientific consensus as there is no legitimate rationale for retaining the DNA samples after they have been profiled and the profile has been entered into the database. Additionally, policy should place limits on the loci analyzed to those containing no known genetically revealing information, and encode the results as a sequence of digits, similar to what CODIS already does.

The profile should be stored in a single, national repository, where access could be strictly supervised and limited to law enforcement personnel only. In addition to access, its *use* should be clearly and unmistakably delineated. Function creep must be kept steadfastly in check. Place restrictions on the use of data for law enforcement purposes only – as opposed to Massachusetts' authorization, for example, of any disclosure for "advancing other humanitarian purposes" (Mass. Gen. Laws Ann. ch. 22E, §§ 10, 15). DNA should be used for nothing other than the limited purpose of identification, and a tough privacy policy should be set in place to conform to the Constitution's requirements. While justifiable to collect DNA samples without consent for criminal investigations, collecting DNA for other purposes, such as producing income, should be banned. Hard-line stances must be taken in cases when purported public interest comes into play, such as in medical research or use in civil litigations (such as determination of paternity).

With the proper safeguards in place, a national DNA database that includes a genetic profile of the whole populace would be an unprecedented tool in the fight against crime. But by itself, a national database alone would be an ineffective resource. Only when coupled with solid police work, and weighed evenly with other physical and forensic evidence left at a crime scene, will its usefulness and purpose for convicting the guilty and freeing the innocent come to fruition.

CHAPTER 6: CONCLUSION

Many ethical arguments shroud the issue of DNA fingerprinting and DNA databases. Many of the problems arise because of the public's lack of knowledge of the topic, while others have a general distrust of the government. Whatever the reason, the potential of this new technology to greatly assist criminal investigations (and many other practical uses) should not be overlooked. However, there must be very clear and well illustrated standards for the collection of DNA and its databasing.

Throughout years of research, DNA fingerprinting has grown immensely. A key issue that has risen is who should have to give DNA samples to be stored in a database. The various stances that people take are: no one should have to give their genetic information, only convicted criminals, only sex offenders, while others say that everyone should give their DNA sample. The government has already begun taking DNA samples and storing them on the CODIS system described in Chapter 5. Each state has adopted its own legislation on who needs to give up their DNA and who is allowed to use the information stored. Since the issue is so controversial, the collection of DNA, specifying which individuals should give up their genetic information, and listing the facilities allowed to store it really need to become standardized. Doing this would potentially help eliminate some of the confusion between interstate and federal laws. Every state should have the same requirements for who is required to give up a DNA sample. Also, the means for collecting the samples as well as storing the information should also be uniform throughout the states.

The storage of DNA has started to become more standardized. Founded by the FBI, the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) was created to bring local laboratories and the FBI laboratory together. The Crime Laboratory Accreditation Program is a voluntary program in which any crime laboratory may participate to demonstrate that its management, operations, personnel, procedures, equipment, physical plant, security, and personnel safety procedures meet established standards. Accreditation offers distinction in the field and, in theory, shows that a lab is committed to unbiased scientific discovery, but this should only be one aspect of a lab's overall quality assurance program. With the greater regulation of DNA acquisition and storage of information, cases like the O.J. Simpson Murder Trial would not be faced with such controversial evidence.

This brings up another valid point. The collection of the DNA must be followed by a strict guideline and procedure as recommended by the FBI's TWGDAM group following the People v Castro case (1989). By doing this properly throughout every organization, the credibility of the evidence submitted is increased. The authors of this IQP agree with the current Massachusetts legislation requiring persons *convicted* of *all* felonies (not just the previously required *violent* felons) to submit their DNA to CODIS. We also support (though less strongly) the more radical idea of mandating all *suspect's* DNAs to be submitted to CODIS. We also agree that the larger the database, the more accurate it is for defining probabilities, thus we support those who voluntarily donate their DNA to the database. The issue of racial prejudice was expressed in Chapter 5 when collecting suspects and criminals' DNA, however, it should be noted that this evidence could potentially save them from being falsely convicted in the future. Once

the DNA sample is taken, there needs to be legislation mandating that the information entered in the database includes only the 13 core forensic loci, which lack any known medical information. And the legislation must also mandate destruction of the original DNA sample to avoid the possibility of obtaining any medical information from the sample in the future. The issue of eugenics must not be taken lightly.

If the government were to sell people's genetic information to private businesses, like the recent incident in Iceland, then the public will continue to lose trust into the motives of the government with DNA fingerprinting. However, the 13 core loci CODIS currently uses contains no known medical information. Once the sample is taken and documented, it is destroyed, thus it truly seems as if the government is taking a very strong step towards securing the rights of the people who have their genetic information recorded.

It is important to see the potential of DNA fingerprinting as an extremely powerful tool in criminal cases and also many other applications. Even though the technnology is still relatively new, already much legislation exists to protect the rights to privacy of the individual. There have been great steps towards protecting the rights of individuals. There must be strict legislation on who is able to use the information available and for what specific purpose. There has to be a very strong check system to ensure that this new database technology is used only the way it was intended. With these proper steps taken, and some education for the general public, the court system as well as the public may begin to have confidence in this powerful new technology.

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