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DNA FINGERPRINTING

An Interactive Qualifying Project Report

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ABSTRACT

This project was performed to investigate the history and current processes of DNA fingerprinting, and to show how it has affected society. Current types of analyses for DNA fingerprinting were described and discussed. Also, proper procedures that must be used when collecting, transporting, and storing DNA evidence were outlined. An overview of several landmark court cases showed how DNA fingerprinting slowly progressed through the years and eventually was allowed into US courts. Several sensational court cases were also described to illustrate how DNA fingerprinting can be used years after crimes have been committed.

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PROJECT OBJECTIVES

This IQP was undertaken to study DNA fingerprinting technology and to document the impact it has had on society by examining legal issues that have arisen in the past and current ethical debates concerning the use of DNA databases and their use by the government. Chapter-1 outlines DNA fingerprinting technology, describing how DNA fingerprints are performed and how it is used. Chapter-2 discusses the proper collection and storage procedures for DNA samples to prevent DNA degradation and contamination. Chapter-3 investigates several landmark court cases that set legal precedence for admitting DNA evidence in the courtroom. Chapter-4 further describes some of the court cases more familiar to the public, some sensational in origin, reviewing the power of DNA technology for past and current cases. Chapter-5 discusses DNA databases (law enforcement databases and medical databases) and their uses, and explains some of the ethical issues accompanied for each type. Finally the authors will make conclusions based on the research they have gathered on this sensational technology.

CHAPTER-1: DNA FINGERPRINTING, DESCRIPTION AND TYPES

Peter Tuma

Introduction

No two traditional fingerprints are exactly alike. Every person in the world has unique fingerprints, none of which are identical to another person on the planet. Similarly, every person has a unique DNA sequence, meaning that no two people anywhere in the world have the exact same DNA, with the exclusion of identical twins. As humans, we share 99.8% of our DNA with every other person on the planet, however, the 0.2% that differs enables scientists to distinguish identity (Trendy Science, 2007). This 0.2% is the part of the genome used today in DNA profiling, also known as DNA fingerprinting. DNA fingerprinting is a technology which utilizes the differences in peoples' DNA to identify a specific individual, and it is proving to be immeasurably useful to society, where it can be used for identifying familial relations, identifying offenders or innocent persons in criminal cases, identifying unknown human remains, or identifying archaeological specimens. The purpose of this chapter is to introduce the technology of DNA fingerprinting, as a prelude to discussing its ethics and legalities in later chapters.

DNA Chemistry and Terminology

The human body, as well as every other living creature, is made up of cells. Cells can be described as the building blocks of life as they are the functional units that make up larger organisms. In humans, there are hundreds of different types of cells, each with its own function. A skin cell is much different from, say, a heart cell. Every cell in the human body has a nucleus

(except for the red blood cells which are non-nucleated), and within this nucleus each cell carries DNA.

DNA contains the genetic code that tells the cell what to do and gives it specific properties. This genetic code is what makes us who we are. DNA, the shortened and almost exclusively used form of Deoxyribonucleic Acid, is the genetic coding that exists in every living thing, except for RNA viruses. Chemically, DNA is made up of nucleotides. A nucleotide (**Figure-1**) consists of a sugar (deoxyribose) bound on one side to a phosphate group and bound on the other side to a nitrogen base (Meeker-O'Connell, 2004). Four different nitrogen bases are found in DNA: adenine (A), cytosine (C), guanine (G), and thymine (T). The deoxyribose sugar and phosphate molecules covalently bond together to form the sugar-phosphate backbone of DNA.

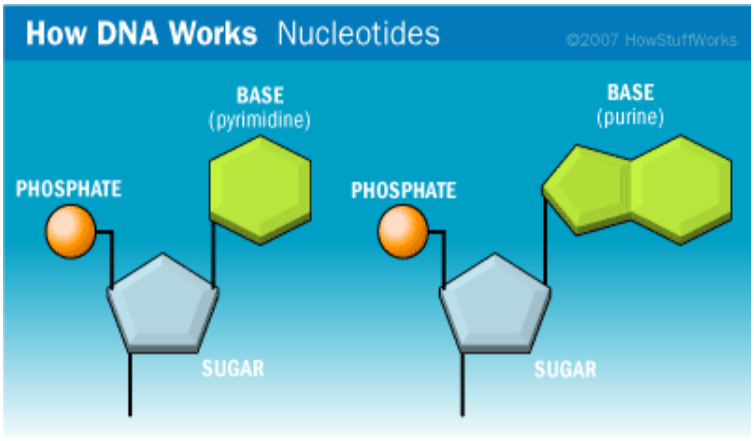

Figure-1: Diagram of a DNA Nucleotide. The nucleotide is the basic building block of nucleic acids, and consists of a base (green) and deoxyribose sugar (gray), and phosphate (orange). (Freudenrich, 2007)

Structurally, DNA is a double helix (**Figure-2**), with two strands of genetic material spiraled around each other (Betsch, 2007). The double helical structure of DNA was discovered in 1953 by Francis Crick and James D. Watson (Crick and Watson, 1953). In 1962, Crick,

Watson, and Maurice Wilkins were awarded the Nobel Prize in Physiology or Medicine "for their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in living material" (The Nobel Prize, 2011). The double helical structure of DNA means that there are two strands of nucleotides loosely bonded together. Although there are four different bases in DNA, chemical shapes and distances dictate that there are only two possible base-pairs, adenine only bonds with thymine, and cytosine always bonds with guanine. This results in the two strands consisting of complementary sequences.

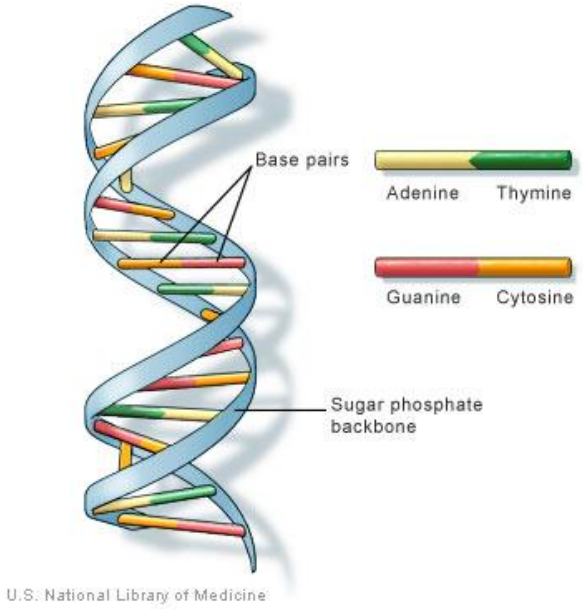

Figure-2: DNA Double Helical Structure. DNA has a spiral staircase-like structure. The steps are formed by the nitrogen bases of the nucleotides (colored) in which adenine pairs with thymine and cytosine with guanine. Photo courtesy U.S. National Library of Medicine.

DNA base pairs form long chains which spell out genetic words, or genes, which tell our cells what to do. The order of the base pairs determines the function of the gene (Trendy Science, 2007). A copy of a human's DNA contains about three billion base pairs, spread out over 23 chromosome pairs, encoding approximately 50,000 genes (Micro 7, 2004).

Chromosomes are strands of DNA containing genes. One chromosome by itself does not contain the full human DNA sequence, instead the full sequence is spread across 46 chromosomes, 23 from each parent. With so many base pairs, the human DNA molecule would be about 1.8 meters if fully stretched out. To fit all this material into a nucleus, the DNA is twisted around bead-like proteins called histones. The histones are also coiled tightly into higher loops to help form the chromosomes (Meeker-O'Connell, 2004).

DNA Loci

With approximately 3 billion base pairs contained in one set of human DNA, it is clear that it is not practical to analyze DNA in its entirety for thousands of forensic DNA samples, thus, in 1997, the US Federal Bureau of Investigation (FBI) announced the selection of 13 core loci (locations) within the human genome to be analyzed when entering DNA profiles into their large DNA database, CODIS (Combined DNA Index System) (University of Arizona, 2006). These 13 core loci are the short sections analyzed when performing DNA fingerprint analysis on human subjects.

DNA STRs and VNTRs

All DNA fingerprinting analyses focus on sites of repeating DNA sequences, as these sites are the most likely to differ between individuals. These sites usually do not encode any proteins, so there is no advantage to an organism keeping the repeat sequences conserved, so these sites vary in the number of repeats at that location. There are two classes of repeat sequences: short tandem repeats (STRs) and variable number of tandem repeats (VNTRs). STRs are short sequences of DNA about 2-5 base pairs long, repeated numerous times in a head-tail

manner, i.e. the 16 bp sequence of "GATAGATAGATAGATA" would represent 4 head-tail copies of the tetramer "GATA" (The Biology Project, 2000). A VNTR is much like a STR, except a VNTR is longer, usually 10-100 base pairs repeated many times (VNTR, 2011). Because STRs are so short, they can be amplified by polymerase chain reactions (PCR) (discussed below), so STR analysis is fast and sensitive. But PCR is so sensitive, it is prone to contamination. VNTRs are usually too long to be analyzed by PCR, so they are analyzed by non-amplifying techniques such as the RFLP.

DNA Fingerprinting Types

There are two main types of DNA fingerprinting used today: amplifying and non-amplifying.

Non-Amplifying Type DNA Fingerprints

Historically, the first technique used to distinguish between different human sequences for identification purposes was a non-amplifying restriction fragment length polymorphism (RFLP) (Jeffreys et al., 1985a; Hill, 2004), adapted by Alex Jeffreys in England from an earlier 1970's Southern blot technique. RFLP was also the first type of analysis used in a court case; a paternity case involving immigrants to prove a mother/son relationship (Jeffreys et al., 1985b). RFLP (often pronounced "rif-lip"), is a molecular biological technique used to compare DNAs from two samples. Differences in the lengths of DNA fragments, excised from long DNA molecules by treating them with restriction nucleases, result from small variations in the sequence of DNA at the locations analyzed (Hill, 2004). These differences can result from the

different number of repeating elements at that location, or the addition/removal of a restriction site.

To perform a RFLP analysis, a relatively large amount of DNA is necessary, as many as 25 strands of hair or about a nickel size sample of bodily fluid is needed. Once the DNA sample is obtained and purified, a restriction enzyme(s) is used to cleave the DNA at specific locations, which results in fragments of different lengths for different people. Restrictions enzymes recognize specific sequences of nucleotides and cleave the DNA at these locations. Over 90 different restriction enzymes isolated from different species of bacteria have been identified (Lerner, 2006), and each cleaves DNA at a different sequence. For example, the enzyme HaeIII recognizes the DNA sequence GCGC and it cleaves the bond between middle cytosine and guanine, while the enzyme EcoRI recognizes the sequence GAATTC and it cleaves the bond between the guanine and adenine (**Figure-3**).

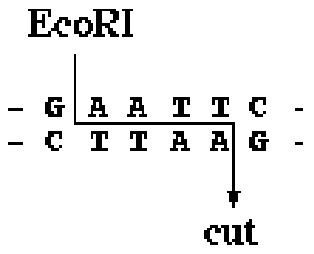

Figure-3: Diagram of the Cutting of DNA by Restriction Enzyme EcoRI. EcoRI cuts DNA strands at the DNA sequence GAATTC , cleaving after the first G. Note that in this case, the cut is not straight through. (Davidson College, 2006)

Depending on the number of cut sites with the restriction enzyme used, thousands of DNA fragments are created. The fragments are separated by size using electrophoresis (**Figure-4**). A charge is placed across a sieving gel. DNA is negatively charged, so it moves towards the

positive anode (Khalsa, 2004), with the smaller fragments moving fastest through the gel (Lerner, 2006).

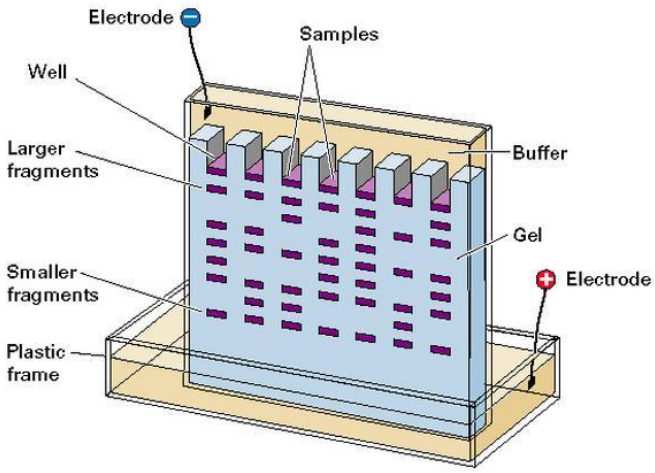

Figure-4: **Diagram of DNA Electrophoresis Used in RFLP Analysis.** Note that the smaller fragments move faster through the gel, and thus migrate farther. Since DNA is negatively charged, it migrates towards the positive anode at the lower end of the gel. (The Molecular, 1998)

Once the gel has been run, the DNA pattern of fragments is blotted to a membrane that allows hybridization to a DNA probe that is complementary to the fragment of interest. The probe is labeled with radioactivity to allow its visualization on x-ray film. The probe is hybridized to the DNA on the membrane, and if a complementary fragment is found, the probe base-pairs with it to visualize it. Thus, the locations of the DNA fragments of interest show up on the film as bands (**Figure-5**). Different samples can be loaded into different lanes of the gel to allow comparisons side by side (Lerner, 2006). The non-amplifying RFLP method can be applied to both VNTRs and STRs, however, in the case of STRs, it is more common to use an amplifying PCR method of fingerprinting since it is faster and more sensitive.

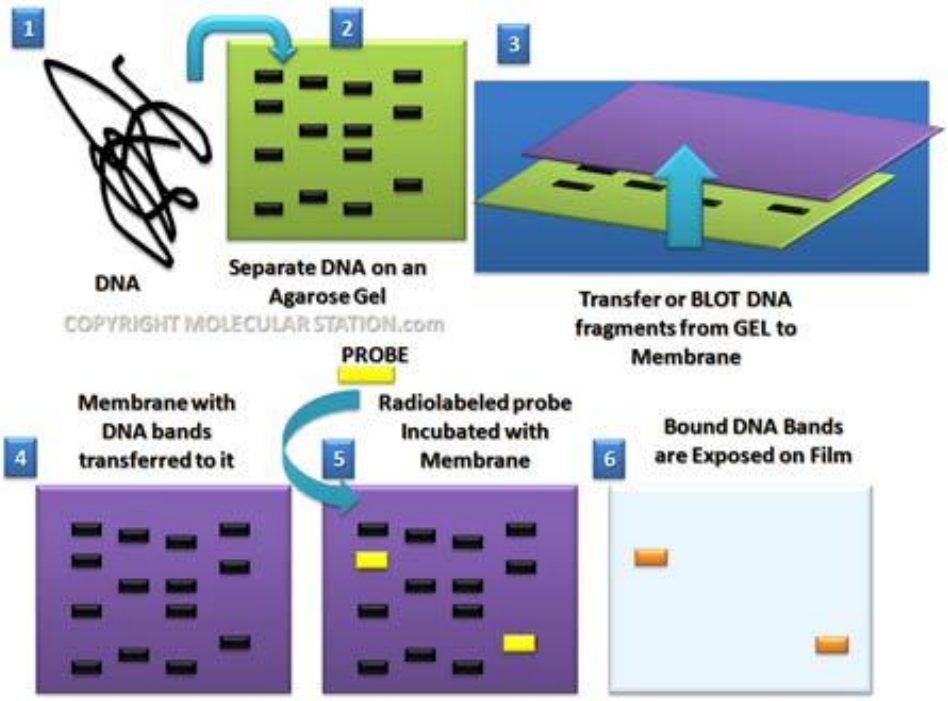

Figure-5: Various Stages of RFLP Analysis. The entire process displays the position of a specific restriction fragment of DNA (orange in lower right panel) in a complex DNA mixture. (Molecular Station, 2008)

Amplifying Type DNA Fingerprints

Although the non-amplifying RFLP method was the first method used for DNA profiling, its use has since declined as it is labor intensive and requires a relatively large amount of DNA. The amplifying type STR/PCR technique holds several advantages over the non-amplifying RFLP method of analysis. First, using an amplifying method, much less DNA is necessary. Instead of needing a fairly large sample size, such as 25 hairs or a nickel size amount of bodily fluid, all that is needed for the amplifying analysis is a single copy of the DNA in question, which can be isolated from a single cell. Second, RFLP type analysis can take a very long time, up to several weeks to complete, while PCR type analysis can be completed in a single day over the course of a few hours. These are the two main reasons for the popularity of STR/PCR

analysis over RFLP. However, STR/PCR analysis is more prone to contamination, while RFLP analysis is not, thus, PCR analysis must be done very carefully. Often times, when a large enough sample of DNA is available, a RFLP analysis will be performed alongside a PCR analysis to ensure that no contamination occurred.

The name amplifying-type fingerprint stems from the use of PCR in this process. PCR, or polymerase chain reaction, is a technique used to amplify the number of copies of a specific region of DNA, to produce enough DNA to easily be seen on a gel for its length (Brown, 2006). PCR is a technique invented by Kary Mullis in 1986 (Mullis et al., 1986) for which Mullis received the 1993 Nobel Prize in Chemistry. Many organisms in nature replicate their DNA in the same way *in vivo*, and PCR imitates this process in the controlled environment of a test tube. A PCR vial contains all the necessary components for DNA duplication: a piece of DNA template, large quantities of the four nucleotides to add onto growing chains, large quantities of sense and antisense primer sequences that flank the STR region of interest, and Taq DNA polymerase that is thermostable and can synthesize DNA at elevated temperatures (Access Excellence, 1992). Taq polymerase is isolated from *Thermus aquaticus*, a sultry bacterium from the hot springs of Yellowstone National Park from which the polymerase was first isolated.

The PCR reaction is a three part cycle, each step being performed in the same vial, but at different temperatures controlled by a thermocycler. The first step of the process splits the double helix of the DNA template to yield two separate strands. This step is called denaturation, and is done by heating the vial to 90-95°C for 30 seconds to a minute. Now that the template nucleotide bases are unpaired, they are accessible to hybridizing to the sense and antisense DNA "primers" that flank the STR site and act to initiate DNA synthesis. DNA polymerases, whether from humans, bacteria, or viruses, cannot copy a chain of DNA without a short sequence of

nucleotides to "prime" the process, or get it started (Access, 1992). Thus, as step two of the process, the DNA primers attach to the single strands of DNA flanking the target sequence, which will allow for the entire desired section to be replicated in the third step. Since the primers cannot bind to the DNA strands at the high temperature of denaturation, step two of the process requires the vial to be cooled to about 55°C for 20-45 seconds. This step is called annealing. Last, the final step of the process is called extension, during which a complete copy of the template DNA is made initiated from the primer site. In this step, the Taq polymerase adds nucleotides to the primer, complementing the template strand of DNA. Since the Taq polymerase works best at around 72°C (the temperature of the hot springs where the bacterium was discovered), the temperature of the vial is raised to this temperature (Access, 1992). This last step of the process completes one cycle of the PCR and takes about 2 minutes. After one cycle, one strand of DNA has become 2 strands of the exact same DNA. Then, the PCR cycle is repeated 20-35 times, producing millions of copies of the target strand of DNA in a few hours (**Figure-6**).

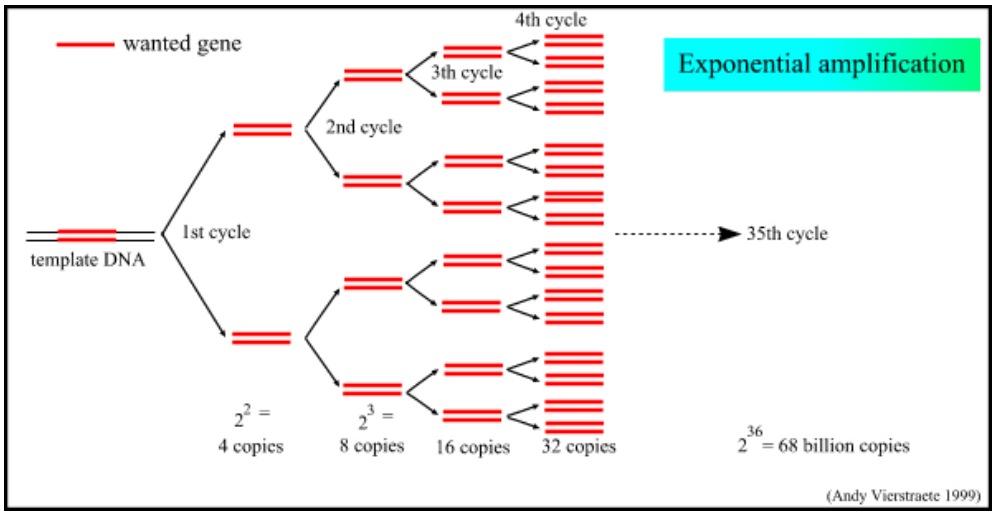

Figure-6: The Exponential Amplification of DNA During PCR. (Vierstraete, 1999)

Once the PCR reaction has been completed and millions of copies of the target STR sequence have been created, the amplified sample is loaded into the gel, next to other samples for comparison, and gel electrophoresis is run to determine the size of amplified fragment. No probe hybridization is usually required to visualize the fragments of interest, so the process is relatively fast. So, with the small sample size of DNA required, and the speed of the process, amplifying type STR/PCR fingerprints are now more common than non-amplifying RFLP analysis. However, with its sensitivity to contamination, the process must be done very carefully and clean room procedures have to be used.

DNA Fingerprinting Applications

In today's technologically advanced world, the applications of DNA fingerprinting are numerous, including determining familial relationships, identifying criminals or the innocent, identifying human remains, or determining from which area a mummy originated. Thus, DNA profiling comes in handy at crime scenes, in the courtroom, at an archeological site, in a hospital, and in the laboratory; and its uses are becoming more widespread.

The most common use of DNA fingerprint analysis is paternity testing. The term paternity testing may be misleading, as "familial" testing can be used not only to prove a relationship between father and child, or between parent and child, but can be used to prove all sorts of familial relationships.

The second most common application for DNA testing is in forensics. In this application, DNA profiles prepared from crime scene evidence or DNA taken off a victim are compared to databases of previous offender profiles to try to identify a match. In addition, DNA profiles taken from evidence of different crime scenes can be used to determine if one perpetrator performed multiple crimes. The DNA is not just used to convict the guilty, it is also used to

exonerate the innocent. In 1992, Barry Scheck and Peter Neufeld founded the Innocence Project, whose mission is to free innocent people who have been unrightfully incarcerated. Since the founding, over 250 innocent people have been exonerated and given back their freedom, and many more have yet to be set free. This would not be possible without DNA fingerprinting. So DNA fingerprinting has come to play a large part in the courtroom, whether establishing a family relationship or proving that the person on trial was at the crime scene or left his DNA on the victim.

However, DNA fingerprinting today also plays a huge role outside the courtroom. Scientists are using DNA to help determine who wrote the Dead Sea Scrolls, and to determine which small piece fits together with another piece. DNA typing can determine which scrolls were written on sheepskin versus those written on goatskin, to help reconstruct the pieces (Biotechnology, 2003). DNA fingerprinting has also been used to establish the degree of relatedness among human fossils found in different geographic locations, thus helping us understand human history and evolution. DNA fingerprinting also plays a role in wildlife management and research, as some countries, including the US, use DNA fingerprinting to prevent the import of caviar from endangered sturgeon species. DNA typing has also been used to monitor the illegal trade of protected species like the sale of whale meat in Japan, and the poaching of protected elephants in certain countries throughout Africa and Asia.

Thus, it can clearly be seen that the uses of DNA fingerprinting in today's modern society are many. In the next chapter, we shall look at the ways scientists are increasing the chances of DNA samples being correctly collected and purified to allow its use in court rooms.

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CHAPTER-2: DNA FORENSICS

Peter Tuma

Introduction

Since the invention of DNA fingerprinting, its importance and use, both in society and in the courtroom have continued to grow. However, DNA evidence was not always as commonly accepted in criminal cases as it is today. From the discovery/invention of genetic fingerprinting by Sir Alec John Jeffreys in 1985 to the present time, many questions have arisen concerning the reliability and morality of genetic profiling. And based on several famous cases of potential DNA contamination or degradation, many advances have been made in the collection, storage, and transportation of DNA evidence. The technology first used in court to establish the relationship of immigrant mother and son has now become the most powerful forensic tools used in courts today. This chapter focuses on the advances in collection, storage, and transport of DNA evidence to increase its acceptance in the court room.

DNA Evidence in Court

When the National Research Council stated in 1992 that DNA testing was a reliable method to identify criminal suspects, the technology eventually entered the mainstream court system following a series of landmark DNA court cases in which the technology was final proven to be reliable and generally accepted in the scientific community (Burns, 2006). But with increased use of DNA in trials, also came its possible contamination and degradation. There were, and occasionally still are, instances of DNA evidence being thrown out of court; the most notable was the OJ Simpson trial where defense attorneys convinced the jurors that DNA evidence *could* have been planted or that the analysis had so thoroughly contaminated the blood

evidence that it was unreliable (Wang, 2001). Thus, the jurors had reasonable doubt, and Simpson was acquitted in the criminal trial (he was later found guilty in a civil trial). Since that time, there have been many advances in the collection, handling, transportation, and record keeping involving DNA evidence. In 2000, the United States Government issued the US Department of Justice Handbook outlining the proper procedures to be used when collecting and handling DNA evidence so that it can be trusted and used in court.

Establishing the Crime Scene

The first step in collecting DNA evidence of high enough quality to be used in court is establishing and securing the crime scene. The scene is simply defined as the actual site or location in which the incident took place, and it is very important that the first officer on the crime scene properly protect potential evidence (Byrd, 2000). When securing the crime scene, some sort of rope or barrier is used around the perimeter to restrict access. It is often necessary to set up multi-level containments consisting of 3 security levels (**Figure-1**). The first area, or containment level-1 (yellow in the diagram), is the most basic and superficial containment: the crime scene tape that surrounds the crime scene itself (Dagnan, 2006). The level-1 containment is set up by the primary responding patrol officers, but may be modified a bit once the investigators show up. If properly set up, the first level of containment should surround all places that have a chance of containing evidence with a little more room for insurance. It is important to remember the possible exits and areas of entrance of the suspect(s), as these may also contain DNA or other types of evidence.

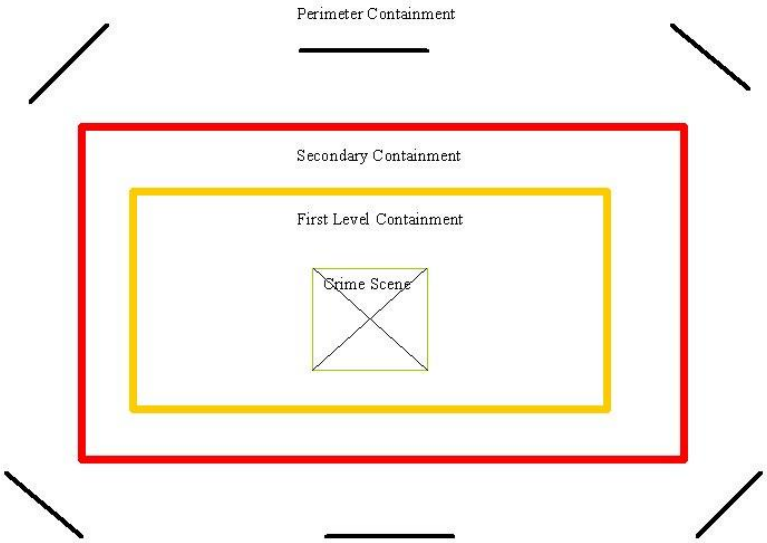

Figure-1: Diagram of Greg Dagnan's Multi-Level Containment System for Securing a Crime Scene. (Dagnan, 2006)

Secondary containment (red in the diagram) greatly increases security, and is set up by the crime scene-processing officers when they arrive. This second barrier is set up to completely surround the first level, creating a buffer zone, so officers and command staff have a place to meet where they cannot be bothered by civilians. Equipment can be stored in this secondary area, and even makeshift desks made from folding tables can be erected. If there is a crime scene vehicle, it can be parked in this area, and the area can serve as an established place for taking breaks and for crime scene trash. A crime scene log should also be kept in this area and signed only by those who enter the first level; conversely, it can be signed by officers as they enter or leave the second level (Dagnan, 2006). Since the first level of containment should have encompassed all possible evidence, no evidence should be found in this second level. If there is any evidence found in the second level of containment however, it is still inside a protected area.

The third, and final, level of containment around a crime scene is perimeter containment (black in the diagram). The point of perimeter containment is that you keep your first and second levels of containment more secure by insuring that unauthorized personnel will not be close enough to intrude upon the crime scene (Dagnon, 2006). This securing is done to varying levels depending of the crime scene. The perimeter can be created using barricades and police vehicles. Roads can be blocked to keep out unauthorized vehicles, and foot traffic can be routed elsewhere. The number of men and barricades needed depends on how many points of access there are to the crime scene, whether media attention has been attracted, and the amount of pedestrian traffic. Although there are many instances when just one or two levels of containment may be adequate, it is always safest to use the multi-level system in order to contain and control the crime scene and insure that there is no unnecessary contamination or tampering with any possible evidence, especially by unauthorized personnel.

Just because the crime scene is secure doesn't mean that it is ok to start collecting evidence. The scene must be documented carefully before anything is touched or moved. The scene documentation is done by the crime scene investigation unit, or CSI unit. Once the CSI unit has arrived and established the second level of containment, their first step is to do an initial walkthrough of the crime scene. The purpose of this is to get an overall feel for the crime scene, to find out if anyone moved anything before their arrival, and to generate initial theories based on visual examination. At this point they also make note of potential evidence, but still do not touch anything (Layton, 2004). Then, during their second walkthrough, the CSI unit thoroughly documents the scene through photographs and sketches. Sometimes a video walkthrough is also used as documentation. The scene is documented as a whole, and any items identified as

potential evidence are also identified, still without being touched. Once the crime scene has been secured and fully documented, it is acceptable to start carefully collecting the evidence.

Types of DNA Evidence

In the human body, there are two types of DNA: nuclear and mitochondrial. Nuclear DNA is contained in all nucleated cells (all cells of the body except red blood cells). At a crime scene, DNA is frequently found in blood, semen, skin cells, tissues, bone, teeth, hair, saliva, mucus, perspiration, fingernails scrapings, urine, feces, etc (Crime, 2000). **Table-I** shows a few different sources of DNA evidence and how much DNA usually resides in each source, along with the PCR success rate.

Table-I: Types of Forensic Samples, Their DNA Content, and Their PCR Success Rates. (Federal, 2000)

SAMPLE	DNA CONTENT	PCR SUCCESS RATE
Blood **1. stain 1 cm x 1 cm** **2. stain 1 mm x 1 mm**	20,000–40,000 ng/mL ca. 200 ng ca. 2 ng	> 95%
Semen **1. on post-coital vaginal swab**	150,000–300,000 ng/mL 0–3000 ng	>95%
Saliva **1. on a cigarette butt**	1000–10,000 ng/mL 0–25 ng	50–70%
Hair **1. root end of pulled hair** **2. root end of shed hair** **3. hair shaft**	 1–750 ng 1–12 ng 0.001–0.040 ng/cm	 >90% <20%
Urine	1–20 ng/mL	
Skin cells **1. from socks, gloves, or repeatedly used clothing** **2. from handled objects (e.g., a doorknob)**		30–60% <20%

ng = nanogram, or 1/1,000,000,000th of a gram; mL = milliliter; cm = centimeter; mm = millimeter

Using polymerase chain reaction (PCR) technology (discussed in Chapter-1) it only takes a few cells to collect enough DNA to amplify and use in court. DNA can be collected almost anywhere off of almost anything, and just because you can't see it doesn't mean that it is not there. Table-II provides a list of commonplace items that might contain DNA, and that may need to be collected as evidence.

Table-II: Sources of DNA Evidence (President's, 1999)

EVIDENCE	POSSIBLE LOCATION OF DNA ON THE EVIDENCE	SOURCE OF DNA
Baseball bat or similar weapon	Handle/End	Sweat, skin, blood, tissue
Hat, bandanna, or mask	Inside	Sweat, hair, dandruff
Eyeglasses	Nose or ear pieces, lens	Sweat, skin
Facial tissue, cotton swab	Surface area	Mucus, blood, sweat, semen, ear wax
Dirty laundry	Surface area	Blood, sweat, semen
Toothpick	Tips	Saliva
Used cigarette	Cigarette butt	Saliva
Stamp or envelope	Licked area	Saliva
Tape or ligature	Inside/outside surface	Skin, sweat
Bottle, can, or glass	Sides, mouthpiece	Sweat, saliva
Used condom	Inside/outside surface	Semen, vaginal or rectal cells
Blanket, pillow, sheet	Surface area	Sweat, hair, semen, urine, saliva
"Through and through" bullet	Outside surface	Blood, tissue
Bite mark	Person's skin or clothing	Saliva
Fingernail, partial fingernail	Scrapings	Blood, sweat, tissue

Collection of DNA Evidence

Now that we know where and what to look for when collecting DNA evidence, we need to discuss the precautions that need to be taken. For example, when taking evidence from blood stains it is important to note whether the stain is wet or dry, as there are different procedures for each. If working with wet bloodstains, there are two possible paths. First, if the stained item is

small and transportable, then it should be packaged in a paper bag (possibly plastic in some cases to prevent contaminating other objects) and brought to a secure location where the package and the evidence can thoroughly air dry. Once dry, the evidence should be repackaged in the original paper bag, or if a new paper bag is used then the old packaging should be placed in the new bag along with the evidence. If the dried bloodstain is on an item too large to be easily transported, then a 1 inch by 1 inch square piece of cotton muslin should be used to absorb the stain. The muslin must be boiled in distilled or deionized water and allowed to air dry prior to its use. This removes interfering factors from the muslin, and the muslin should not be handled with bare hands (Schiro, 2001). Clean forceps should be used to absorb the stain into the cotton, which should then be placed in a paper bag and brought to a secure area where it should be removed from its packaging and allowed to air dry. Once dry, the cotton muslin should be repackaged, either back in its original packaging or in a new paper bag with the old packaging included with the square. Some samples from unstained areas of the material should also be collected as negative controls.

In the case of dry blood stains, there are a few different ways to collect a sample. If the blood is on a small item that can be taken whole, it should simply be packaged in a paper bag or envelope. If the stain is found on something too large to remove from the scene, then one way to collect a sample is to cut out the portion or portions of the item with the stain on them. A negative control area (not thought to contain a stain) should also be cut out, and the pieces should be packaged in separate paper envelopes. If the stain is found on something that cannot be cut, a method called tape lifting can be used. Fingerprint tape is used and placed over the bloodstain and the neighboring negative control area, with great care taken not to touch the sticky surface of the tape with bare hands. A blunt object such as the back of a pen should be used to rub the

backside of the tape and insure good contact is made between the stain and the tape. The tape should then be lifted and placed on a vinyl acetate backing. The label should indicate which stains the samples came from, and they should be packaged in a paper envelope. Another option for collecting a sample from a dried bloodstain is to use a sanitized sharp instrument, such as a scalpel, to scrape the bloodstain into a paper packet. This packet should be labeled and placed in a paper envelope. It is important that the flakes are placed in a paper packet and not into a plastic container as the static charge from the plastic will cause the blood flakes to disperse and stick to the sides of the container (Schiro, 2001). The scraping technique can also be combined with tape lifting, scraping the stain and picking up the scrapings with the technique described above.

Another way to collect a DNA sample from a dried bloodstain is to absorb the stains onto moistened cotton. Either one-half inch length cotton threads or cotton muslin squares can be used. Clean, number 8 white cotton threads can simply be moistened using distilled or deionized water, while cotton muslin must be boiled in distilled or deionized water and allowed to air dry before being moistened with sample. If using the threads, they should be placed on the stain using clean forceps and rolled on the bloodstain, which should absorb the stain into the thread. The process should be repeated until a minimum of four threads have been collected. These threads should then be allowed to air dry in a safe area. Once dry, the threads should be placed in a paper packet which should be labeled and placed in an envelope. The procedure for using the moistened cotton squares on a dry stain is the same as using cotton muslin to absorb a wet stain. Thread or cotton muslin samples should be taken from a negative control area, if possible, and packaged separately.

As mentioned above, blood is not the only source of a DNA sample. There are many sources, and each one has specific procedures that need to be followed. The Police Executive

Research Forum offers a table of all types of DNA forensic evidence which an investigator may come across (**Table-III**). The table also displays the methods of collection, the risks that may be involved for a particular method, and some other special considerations which the investigator should keep in mind.

Table-III: DNA Evidence Collection Methods, Risks, and Special Considerations.
(Turner et al., 2002)

EVIDENCE (TYPE AND FORM)	COLLECTION METHOD	RISKS	SPECIAL CONSIDERATIONS
Dried blood (small items)	If possible, wrap the item in clean paper, place the article in a brown paper bag or box, and seal and label container. Send the whole stained object to the laboratory after labeling and packaging.		
Dried blood (Large items)	Preferred Method: Cover the stained area with clean paper and seal the edges down with tape to prevent loss or contamination	More work for the serologist: bulky items require more storage space	Requires a minimal amount of interaction with the bloodstains by the investigator and allows the serologist to make the decisions involved in collecting the samples
Dried blood (Large items)	Alternate Method #1: Cut out the part of the item with the bloodstain(s). A control sample should also be cut out if available. Both cuttings should go into separate paper envelopes	Investigator must use discretion to determine which stains and controls to collect. Some materials are difficult to cut through.	Dilution and contamination potential eliminated by not using water as the collection medium. Investigator has minimal interaction with the bloodstain, and evidence does not take up much storage space.
Dried blood (Large items)	Alternate Method #2: Use fingerprint tape to lift bloodstain. Place tape over bloodstain and	Investigator must decide which stains and controls to collect. Bloodstains do not lift well off certain surfaces	A fairly easy technique in which the control sample is readily collected. Dilution and

	surrounding negative control area. Lift the bloodstain and place the tape on a vinyl acetate backing.		contamination potential minimized by eliminating the use of water as the collection medium. Requires little storage space
Dried blood (Large items)	Alternate Method #3: Scrape bloodstains into a paper packet with a clean, sharp instrument.	Investigator must decide which stains to collect; when scraped, bloodstains break into small, difficult to-handle flakes; flakes are easily lost.	Dilution and contamination potential minimized by eliminating the use of water as the collection medium. Requires little storage space
Dried blood (Large items)	Alternate Method #4: Absorb stains onto ½‖ long, number 8 white cotton threads moistened with distilled or deionized water.	Dilution and contamination potential is increased due to using water; investigator must use discretion as to which stains and controls to collect.	Stain is concentrated onto a relatively small surface area, requiring little storage space.
Dried blood (Large items)	Alternate Method #5: Absorb stains onto moistened ½‖ x ½‖ cotton squares, following the same procedure as with threads.	Dilution and contamination potential is increased due to using more water.	Stain is concentrated onto a relatively small surface area; easier to handle than threads; requires little storage space.
Wet blood (Small items)	Place small stained items in paper bag (or plastic bag to prevent contamination of other objects). In a secure spot, take item out of bag, and allow the evidence and bag to thoroughly air dry.	Evidence should be refrigerated or frozen immediately, then delivered to the laboratory as quickly as possible. Delays beyond 48 hours may increase the chances of decomposition. More work for the serologist; bulky items use more storage space.	Requires a minimal amount of interaction with the bloodstains by the investigator; allows the serologist to make the decisions involved in collecting the samples.
Wet blood (Large items)	Absorb the stain onto a 1‖ x 1‖ square of cotton muslin. Package it in paper (or plastic to prevent contamination of other objects).	Evidence should be refrigerated or frozen immediately, then delivered to the laboratory as quickly as possible.	Requires little storage space; fairly easy technique to perform; stain is concentrated onto a relatively small surface

			area.
Semen and Seminal Stains on Fabric	Allow any stains to air dry. If damp, allow fabric to dry completely before packaging in paper.		Often found on clothing, blankets, and sheets.
Semen and Seminal Stains on Victim	If victim shows evidence of sexual intercourse, use PERK. If necessary, oral, vaginal, or anal swabs should be taken from the victim. Swabs should be air dried under a fan or moving air source for at least one hour.	The body begins breaking down the various components in seminal fluid through drainage, enzyme activity, pH, etc. Moisture in the swabs allows microorganisms to grow, which can destroy the evidentiary value of the swabs.	Take swabs as soon as possible. Evidence collected and subjected to testing may reveal results from biological material left by other consensual sexual partners unrelated to the offense investigated or other contact with victim by other individuals.
Saliva	Use sterile gauze pad or swabs; allow to air dry. Place in paper, not plastic, containers. Sources of saliva can include envelopes, bottles, cans, gum, food, etc		
Wet Clothing	Hang articles in a room with adequate ventilation and allow to air dry. Label, roll in paper, then store in brown paper bag or box; seal and label container.		Handle fabrics as little as possible
Hair with root sheath	Collect 15-20 representative hairs from the suspect. Place in paper packet and then in an envelope		If a root sheath is attached, DNA analysis using PCR technology can provide information on the likelihood that this hair came from a certain percentage of the population to which the suspect belongs.
Hair without Root Sheath	Collect 15-20 representative hairs from		If there is no root sheath, microscopic analysis

	the suspect. Place in paper packet and then in an envelope	can reveal whether the hair has the same characteristics as the suspect‘s hair.
Stain evidence on Nonabsorbent Materials	On materials such as plastic and metal, shifting the material from a cold to a warm environment may create condensation, destroying the forensic value of the sample. Samples must be packaged so the stain portion is protected. Keep evidence at room temperature and deliver to lab as quickly as possible.	

Preventing DNA Contamination and Degradation

Because extremely small samples of DNA can be used as evidence, greater attention to contamination is necessary when identifying, collecting, and preserving DNA evidence. DNA evidence can be contaminated when DNA from another source gets mixed with DNA relevant to the case. This can happen when someone sneezes or coughs over the evidence, or touches his/her mouth, nose, or other part of the face and then touches the area that may contain the DNA to be tested. Because "PCR" replicates and amplifies DNA in the evidence sample, the introduction of contaminants or other unintended DNA to an evidence sample can be extremely problematic, as it too will become amplified. With such minute samples of DNA being copied, extra care must be taken to prevent contamination (Crime, 2000). In order to prevent the contamination of DNA evidence, caution must be used from the time of response

to until the trial is over, and often many years after that, depending on the state, in case the evidence needs to be retested.

The evidence must be collected and handled with care; gloves must be worn and changed often, clean utensils (using disposable instruments is very practical) must be used, everything must be packaged properly in paper (not plastic, as plastic retains moisture and greatly increases the chance of DNA degradation), and constant caution must be taken to avoid cross contamination, either between separate pieces of evidence or between evidence and the investigator/officer. When transporting and storing evidence that may contain DNA, it is important to keep the evidence dry and at room temperature. Direct sunlight and warmer conditions may be harmful to DNA, so avoid keeping evidence in places that may get hot. Once the evidence has been secured in paper bags or envelopes, it should be sealed, labeled, and transported in a way that ensures proper identification of where it was found and the proper chain of custody of any person collecting or using the evidence (Crime, 2000). Chain of custody is defined as documentation of the movement and location of physical evidence from the time it is obtained until the time it is presented in court, and is extremely important to ensuring DNA evidence can be trusted will be allowed in court.

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Chapter-3: Landmark DNA Court Cases

Joseph Pasquarelli

Introduction

Deoxyribonucleic acid (DNA) fingerprinting analysis has become one of the most influential and used tools of forensic scientists today. But it took many years for the technology to become standardized and generally accepted in the scientific community to be used in courts. Like anything that is not fully understood by the community, DNA fingerprinting was not generally accepted when it was first developed. It took years to prove it was reliable enough to serve as a resource in the court room, and was put under great scrutiny by the legal system. This chapter will go into key components of landmark court cases involving DNA fingerprinting, and show how it developed into the Five Prong test used today.

Frye v US (1923)

In 1923, James Alfonzo Frye was charged with, and convicted of, a brutal second degree murder *(Frye v. U.S., 1923).* Frye took a systolic blood pressure test, the father of the modern day polygraph, to attempt to dismiss himself from the trial. He passed the test, but the courts would not allow his expert witness to testify on behalf of the then new blood pressure test to allow its results to be accepted in court. The courts felt the evidence was not admissible in court due to its lack of general acceptance by the scientific community.

Frye's counsel then appealed the guilty verdict to the Appeals Court of the District of Columbia, saying it was wrong to not allow their expert witness to testify upon behalf of the new test. But the court concluded that the original guilty verdict stood, so James Alphonso Frye was

found guilty of second degree murder. The court stated that the expert testimony regarding systolic blood pressure testing had not gained large enough standing and recognition within the scientific community *(Frye v. U.S., 1923).* Scientists could not prove the precision or dependability of the test to the court room at that time. Also there were no prior cases in which this form of testing was used to prove guilt or innocence. The systolic blood pressure test worked much like a modern day polygraph test (whose results also remain unaccepted in most courts), administered by an examiner who watches the individual's heart rate, blood pressure, respiratory rate, and perspiration levels to see if any drastic changes occur as the person is asked a series of questions. According to the theory, when a person is telling the truth, the statement comes easy to them and does not cause any physiological changes. But when a person lies, they must think about the statement they are about to make which causes physiological changes. "The theory seems to be that truth is spontaneous and comes without conscious effort, while the utterance of falsehood requires a conscious effort" *(Frye v. U.S., 1923).* Modern courts do not accept lie detector results, as it is now well known that some individuals can manipulate the results of the test.

The Court of Appeals for the District of Columbia decided that the acceptance of evidence from a systolic blood pressure test was inadmissible in court because it did not hold the undoubting support of the scientific community. This case set a precedent known as the *Frye Standard*, which was used for decades to determine what was considered acceptable scientific evidence. Frye v US also set a standard for allowing expert testimony in court for helping explain a complicated, unknown, technical subject.

US v Downing (1985)

US v Downing was very similar to Frye v US, in that it further elaborated upon the admissibility of scientific evidence into trials. The Downing case dealt with the use of expert testimony and eyewitness accounts, unlike the Frye case which dealt with the admissibility of scientific tests. John W. Downing was accused of mail fraud, wire fraud, and interstate transportation of stolen property in the United States District court of Pennsylvania *(US v Downing, 1985).* Downing was accused of giving false information, such as his credentials, in order to establish a foothold in other businesses. He would become very friendly with other business owners, and offer to sell their product. They would ship him their products on credit, but then Downing would sell the product without paying the company. The prosecution used eyewitness accounts from various scammed vendors to convict Downing of his crimes. Downing and his defense attempted to use expert witness testimony to explain how unreliable an eyewitness could be, but the court would not allow that to happen, citing Rule 702 saying the expert witness would not be that helpful. The vendors took the stand identifying Downing, and the court convicted him.

But Downing's defense was not done; they appealed their case to Judge Becker and the Third Circuit Court of Appeals, and were successful. The Third Circuit Court of Appeals found the District Court at fault for denying the expert witnesses. The court found flaws within what the prosecution had brought to the table. First and foremost, the prosecution stated that they had acquired more evidence such as fingerprints and handwriting which linked Downing to the crimes *(US v Downing, 1985)*, but this was false because no such evidence was ever brought up during the trial, and the defendant had been convicted solely on the basis of eyewitness testimony. Secondly the prosecution claimed the expert witness would "usurp" or assume the

function of the jury *(US v Downing, 1985).* The Court of Appeals decided to use a prior case from Arizona, *Chapple v State,* which provided a precedence for allowing an expert witness when needed. The Court felt that even without the use of the eyewitnesses, the jury would be able to make the correct decision based on a "proper cross examination" *(US v Downing, 1985).* The court also stated that expert testimonies such as these sometimes fit the criteria of *Rule 702* also known as the helpfulness rule, stating that expert testimonies would help the jury make a proper decision because it would allow the jury to better understand the information being presented to them during the trial. Judge Becker held that the District Court was wrong in its exclusion of the expert witness without a hearing, and sent the case back to the District Court with instructions to hold a pre-trial hearing on whether to allow the expert testimony.

Following the hearing, the court decided not to allow the witness, as it did not carry sufficient reliability to aid the jury, would overwhelm, confuse, or mislead the jury, and would not be of value due to the number of eyewitnesses whose interaction with Downing was significant. The court excluded the expert in this instance, so the original guilty verdict stood.

The Downing case's importance is seen every day, because it calls for a pre-trial hearing in which both sides present evidence to the judge who decides whether it will be admitted to the court for that particular trial. US v Downing also reinforced Rule 702 and its helpfulness standard, which was an easier standard to comply with than the Frye standard of general acceptance.

Andrews v State of Florida, 1988

In 1988, The Court of Appeals of Florida considered the case of Tommie Lee Andrews who was accused of aggravated battery, rape and armed burglary. The victim stated to the police

that the attacker had forced her down and kept her there by threatening her life with a razorblade. The victim then stated that she was raped by the defendant before he fled the scene of the crime. The victim had cuts all over her body from the razor, and semen was discovered in her vagina from the attacker *(Andrews v. State of Florida, 1988).* One of the main suspects had been Andrews due to his suspected involvement in rape cases all over the Orlando area, but they could never pin a crime on him until now as he left semen at the crime scene. Through lab testing it was discovered that the producer of the semen was blood type "O" which meant the attacker was a secretor, someone that has blood in bodily fluids such as semen. But since the victim was also blood type "O" and not a secretor, the court established that her attacker must be a secretor and that he must also be type "O". So for the first time in U.S. court history, the semen underwent DNA fingerprinting analysis to see if it matched the DNA of and sure enough his DNA matched the DNA left in the victim *(Andrews v. State of Florida, 1988).*

The judge organized a pretrial hearing, as mandated by the Downing case, to determine whether to allow the DNA evidence to be used in the trial. But because this technique was so new to the scientific community it was not generally accepted by the scientific populous, so the trial judge relied on Rule 702 stating the fingerprinting technique was very reliable, so the DNA results were deemed admissible in court. While observing the helpfulness and dependability of the evidence, even though it was a new unproven method, the court considered the "novelty of the new DNA profile technique, the existence of a specialized literature dealing with the technique, the qualifications and professional stature of expert witnesses, and the non-judicial uses to which the scientific techniques had been applied" *(Andrews v. State of Florida, 1988).*

During the trial the judge allowed for an expert witness to take the stand to explain the process of DNA fingerprinting to the court. His name was Dr. David E. Housman, and he

explained the method of "restriction fragment length polymorphism" (RFLP) (discussed in Chapter-1). The courts were satisfied with his explanation of the process, and felt it was good enough to allow the jurors to make a well thought educated decision when it came to the verdict of this trial. The DNA evidence was included at trial, and Andrews was found guilty.

Andrews v. State of Florida was the first U.S. case to allow the use of DNA fingerprinting analysis, arguing it was reliable enough to satisfy Rule 702. Roughly ten years prior to this trial, DNA had been used for non-judicial purposes, and in those cases had not led to flawed results. DNA fingerprinting technology was also based on many scientific theories that had plenty of scholarly literature to support the subject, showing the court that it was a helpful and reliable practice, so they decided to allow the evidence to be used in trial. This acceptance of DNA fingerprinting lasted only one year until the Castro case of 1989.

People v Castro (1989)

Joseph Castro was suspected of having murdered Vilma Ponce, a woman who was 7 months pregnant at the time. Castro was arrested in February of 1987 and accused of stabbing Vilma Ponce to death and subsequently killing her unborn child. When the police arrested Castro and brought him into the station, they discovered his wristwatch had blood stains which further led them to believe he had committed the murder. The court tested Vilma Ponce's blood and the blood found on Castro's wrist watch, and through DNA fingerprinting analysis they concluded that the blood of the victim matched the blood on the wristwatch.

Castro's defense team did not accept this finding; they felt as if the lab that performed the DNA test did not do so properly. Once the defense proclaimed this to the court, it caused the *People v Castro* case to become one of the most scrutinized cases of the new DNA technology.

The Bronx County Supreme Court stated that: "(1) with generally accepted scientific tests performed properly, DNA identification evidence is admissible, and (2) the testing laboratory did substantially perform scientifically accepted tests with regard to evidence of *exclusion*, but failed to use generally accepted scientific techniques for obtaining reliable results with respect to evidence of *inclusion*" *(People v. Castro, 1989).*

This case led to the development of a three prong standard. The courts developed this standard to further advance the process known as DNA fingerprint analysis and allow for its use in cases in the future. The three prong test stated as follows: Prong 1, Is there a theory, which is generally accepted in the scientific community, which supports the conclusion that DNA forensic testing can produce reliable results? Prong 2, Are there techniques or experiments that currently exist that are capable of producing reliable results in DNA identification and which are generally accepted in the scientific community? Prong 3, did the testing laboratory perform the accepted scientific techniques in analyzing the forensic samples in this particular case? *(People v. Castro, 1989)*

When applying this new 3 prong standard to the Castro evidence, the courts argued that when pertaining to Prong 1 "the evidence in this case clearly establishes unanimity among all the scientists and lawyers that DNA identification is capable of producing reliable results" *(People v. Castro, 1987).* They supported this by relying on a scientific publication known as "DNA Typing: Acceptance and Weight of the New Generic Identification Tests. By Thompson and Ford *(People v. Castro, 1987).* Thompson and Ford's work showed the court that little is controversial about DNA typing within the scientific community, and the repeated success that occurs in the lab when using these tests shows that it should clearly be admissible in a court room. This shows how the evidence in the Castro case met the criteria of the first prong.

With respect to the second prong, when the court investigated the DNA testing done in the Castro trial they stated that "the techniques and experiments performed in this case are not novel or recently discovered, they have been in use in laboratories in the conducting of DNA analysis in diagnosis, clinical and experimental settings for years" *(People v. Castro, 1989).* For example, within the year 1989 itself, there were 8 analyses conducted for clinical and diagnostic purposes which all gained scientific acceptance. This demonstrated to the court that the DNA test used to prove Castro had Ponce's blood on his watch complied with the second prong of the three prong standard.

With respect to the third and final prong, the court felt as if "a pre-trial hearing should be conducted to determine if the testing laboratory substantially performed the scientifically accepted tests and techniques, yielding sufficiently reliable results to be admissible as a question of fact for the jury" *(People v. Castro, 1989).* When the court asked the laboratory, they proclaimed they were capable of conducting reliable tests because they usually follow accepted scientific procedure, but for this particular case they had not done so. So since the lab failed to run proper tests, the court would not allow the use of the DNA evidence in this particular trial if it was used to prove a person was part of the crime, although they would allow the DNA evidence if it proved someone was *not* involved in the murder (exclusion is easier to prove).

Although the DNA evidence was not allowed in this particular trial, it proved moot, as the case never went to trial. Castro pled guilty without a trial. But the Castro case produced the three prong test for deciding whether to include DNA evidence for future cases. And it created a demand to standardize the technology, to help ensure the testing was performed correctly. A group was created by the FBI known as the "Technical Working Group on DNA Methodology" or TWGDAM which helped standardize the DNA analysis process (TWGDAM, 2008).

US v. Two Bulls, 1990

The Castro trial brought us the three prong test which provided a template to determine whether DNA evidence could be used in a particular trial. The Two Bulls case added two more prongs to the test, requiring a longer pre-trial hearing relying on the trial judge to weigh each side's argument and decide whether the evidence should be admitted in court.

US v. Two Bulls was a trial of Mathew Sylvester Two Bulls Jr. who was accused of, and found convicted of, aggravated sexual abuse and sexual abuse of a minor in the United States District Court in South Dakota. When the Case went to its pretrial hearing, the court deemed the DNA evidence was going to be admissible during trial based on Castro's three prongs, but Two Bull's legal counsel appealed this because they felt that the third prong of the three prong standard was not met, as Two Bull's counsel discovered that the district court had no clue whether the FBI had actually run the DNA testing analysis properly. The Appellate Court decided that the original District court had not complied with prong 3, so the DNA evidence was not admissible *(US v. Two Bulls, 1990).*

In response to the ruling, the prosecution felt as if "Castro stands alone and provides too stringent a standard, making long drawn out testimonial procedures before trial necessary" *(US v. Two Bulls, 1990).* They also felt as if Rule 702 or the Frye standard was too unconventional to apply to DNA evidence. The Court of Appeals concluded that the trial court was wrong when allowing the DNA evidence without truly understanding the process from which the FBI obtained the evidence, so required the case be returned to the trial court and be subjected to an extra-long pre-trial hearing in which each side would tell why the evidence should or should not

be allowed in the trial. This became known as the Five Prong Test which stated that the court should decide:

> **1**. Whether DNA testing is generally accepted by the scientific community.
>
> **2.** Whether the testing procedures used in this case are generally accepted as reliable if performed properly.
>
> **3**. Whether the test was performed properly in this case.
>
> **4**. Whether the evidence is more prejudicial than probative in this case.
>
> **5.** Whether the statistics used to determine the probability of someone else having the same genetic characteristics is more probative than prejudicial under Rule 403.
>
> (*Two Bulls v. U.S, 1990*)

The Two Bull's case was sent back to the trial court, and they underwent a new pre-trial hearing due to the five prong test. The DNA was deemed admissible to the court and Two Bulls received a guilty verdict of both aggravated sexual assault and sexual assault of a minor.

People v. Miles 1991

Reggie E. Miles was convicted of two counts of home invasion, five counts of aggravated criminal sexual assault, one count of criminal sexual assault, one count of aggravated unlawful restraint, one count of armed robbery, and two counts of residential burglary by the Circuit Court of Vermillion County in Illinois. Police collected a slew of DNA evidence in this case, they used an articulate expert to help explain the technology, and it was deemed admissible in trial. Miles counsel appealed the case to the Court of

Appeals proclaiming that the DNA evidence submitted to the court was far too complex for the general public to understand *(People v. Miles, 1991).*

But the Court of Appeals stood by the Circuit Court's original decision to allow the DNA evidence to be used in trial, declaring that the expert witness had thoroughly and clearly explained the process behind obtaining the evidence, and that it was good enough to assist them in making a correct verdict. This meant that Miles earlier guilty verdict was upheld *(People v. Miles, 1991).*

This case further showed how DNA fingerprinting analysis could be used to identify a criminal, and how an expert witness could be used to properly educate a jury on the steps taken to obtain the evidence to help the court come to an educated decision on whether to allow the evidence.

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Chapter-4: Sensational DNA Court Cases

Joseph Pasquarelli

In the previous chapter, specific court cases were presented to show how complex technology like DNA analysis is carefully considered prior to its acceptance in the courtroom as evidence. In this chapter, court cases will be presented that gained much media attention in which DNA was, or will be, used to help solve the crime.

The Boston Strangler

In the early 1960's, thirteen women were brutally murdered in the Boston area (**Figure-1**). The public believed that one man committed all these crimes because they were all committed in a very similar fashion. But some in the Boston Police Department felt it would be difficult for one man to commit all the crimes. The crimes shared three important situations: First, the victims' homes were not forcefully entered. Second, every victim had been strangled and sexually assaulted. And third, every victim was strangled with a piece of their own clothing, usually something they were wearing at the time of their death *(Bardsley & Bell, 2003).*

Figure-1: Photographs of the 13 Victims of the Boston Strangler.
(Corbis, n.d.)

The first person to fall to the Boston Strangler was 55 year old Anne Slesers. She was murdered on June 14, 1962 in the late evening. Her body was not found until her son, Juris, came to her apartment to bring her to church. He did not get an answer at the door so, being worried for her safety, he forced his way in. He found his mother on the bathroom floor with a piece of her robe tied around her neck. It was later discovered that this was used to strangle her to death after she had been sexually abused. Juris also noticed that the apartment had been ransacked as

if someone robbed the place, but he later determined that nothing was taken *(Bardsley & Bell, 2003; Boston Strangler, 2007).*

The Boston Strangler did not wait long to strike again, after about three weeks he attacked and killed two more women. The first was 68 year old Nina Nichols who was found with two her nylon stockings tied around her neck into a bow. Her body also had many signs of sexual assault as did the body found 3 weeks prior. This crime scene also was ransacked but nothing was missing. Fifteen miles down the road in Lynn, Massachusetts, Helen Blake had also been strangled with her nylon stockings on that same day. Helen's apartment also had been torn apart, but nothing was taken except for two rings that the victim had been wearing at the time. There were also signs of semen on Helen's body *(Bardsley & Bell, 2003; Boston Strangler, 2007).*

These three murders greatly worried the Boston Police Department, and caused anxiety for women in the Boston area. The Police warned the public about the situation, saying they should not leave their doors unlocked or allow any strangers into their home. The FBI was brought onto the case. The Police brought known sex offenders living in the Greater Boston area in for questioning. Boston as a whole was working vigorously to try to identify the killer *(Bardsley & Bell, 2003; Boston Strangler, 2007).*

But the Boston strangler still had his eyes on more victims even though all of Boston was looking for him. A few weeks after his second set of murders (after 3 victims) he murdered 75 year old Ida Irga by choking her and then sexually abusing her. He left her body in front of the doorway to her living room at her apartment in the West End. Later that evening across the city in Dorchester, the strangler killed another woman Jane Sullivan who was 68 years old at the time. She was found in her bathtub with nylons around her neck, and was not found until 10

days after her death. As with the other crimes, there was no forcible entry, but her home had not been ransacked *(Bardsley & Bell, 2003; Boston Strangler, 2007).*

The Boston Strangler did not strike again until December 5th, when he murdered 21 year old Sophie Clark. She had been strangled with her own nylons in her apartment right down the street from the first victim's residence. The Strangler seemed to have switched his modus operandi attacking younger more attractive women. Sophie was the first of a long line of new victims of the Boston Strangler *(Bardsley & Bell, 2003; Boston Strangler, 2007).*

After a few months, in early March, the strangler struck again in Lawrence, Massachusetts where Mary Brown, 68, was found beaten, raped, and strangled. Not long after the killing of Mary Brown, Beverly Samans, a 23 year old graduate student was found stabbed to death with her nylons tied around her neck. But the police noticed that she had not been strangled, and the stab wounds had killed her. She had been stabbed 22 times, 4 times in the neck and 18 times in the chest. Samans was unlike all the other cases because she was stabbed and not sexually assaulted *(Bardsley & Bell, 2003; Boston Strangler, 2007).*

The police were very frustrated and could not identify a suspect, so they brought in a supposed extra sensory perception (ESP) specialist Paul Gordon. After Gordon had spoken to the police and viewed some suspect lineups, he concluded that the killer was Arnold Wallace. The police investigated Arnold, and discovered he was in a Mental Hospital but was out on all the days the victims were killed. They administrated a so called "lie detector test", but found out Gordon had visited Wallace's hospital before he spoke with police, so the police considered it a hoax and sent Wallace back to the Hospital *(Bardsley & Bell, 2003; Boston Strangler, 2007).*

Several more murders occurred, beginning in the summer of 1963 with the death of Evelyn Corbin, he had strangled her with her nylons and then went through her purse but nothing

was stolen. His next victim was Joann Graff, a 23 year old who was also sexually assaulted and strangled with her nylons. Fortunately, this time someone may have seen the killer, one of her neighbors heard knocking on Graff's door in the early morning and looked out and saw someone looking for Graff. A few hours later Graff was dead in her apartment. The Boston strangler's last killing was in January of 1964, over a year after his first killing. Her name was Mary Sullivan, 19 years old. She had been strangled and sexually assaulted. The killer left her body in a mutilated position with a pink scarf around her neck and a New Year's card by her foot for her roommates to find *(Bardsley & Bell, 2003; Boston Strangler, 2007).*

Massachusetts Attorney General Edward Brook took up the case of the Boston Strangler on January 17, 1964, and created a special task force, run by Assistant Attorney General John Bottomly. The task force never found any suspects, but it seemed to give the public a feeling of security.

The strangler case was not "solved" until a man confessed to another set of crimes committed years before the strangler started his work. A few years before the strangler murders, a man committed a series of crimes pretending to be a modeling agent and would sexually assault women in their homes. This man was Albert Desalvo who was 29 at the time. He was coined the "Measuring Man" because he would pretend to be taking measurements of the women while in reality he was attempting to feel them up. Desalvo confessed to committing all the sexual assaults as the "Measuring Man", and also confessed to being the "Green Man", who had committed a series of rapes in the Connecticut area while wearing green pants. Desalvo was sent to Bridgewater Hospital for evaluation and observation *(Bardsley & Bell, 2003; Boston Strangler, 2007).*

While he was at Bridgewater hospital, Desalvo had a ward mate, George Nassar. Nassar was a very clever and manipulating man. Some believe that during their stay together, Nassar convinced Desalvo to plead guilty to the Boston Strangler crimes so Nassar could collect the reward for finding the strangler, and they would split it. It was believed that Desalvo did this with the hope of supplying his family with money during his life sentence. So, on March 6th 1965, Desalvo confessed to the murders. However, not everyone believed that Desalvo was the real killer, many people felt as if Nassar tricked him into admitting it for the money, or even that Nassar himself was the strangler. Some witnesses, when supplied with a photo lineup containing pictures of Nassar and Desalvo, claimed that Nassar was the man at Joann Graff's door. In addition, when asked to supply details of the crimes, some of the details Desalvo got wrong precisely matched the wrong details published in the Newspapers (Lavoie, 2001; Kelly, 2002). The Strangler case never went to trial, as Desalvo was murdered in prison.

With respect to DNA evidence, DNA forensic analysis did not exist in the early 1960's. But based on doubt about Desalvo, years later in 2001, the family agreed to exhume the body of Mary Sullivan. A DNA test performed on semen left in her body did not match Desalvo (Lavoie, 2001; BBC News, 2001; Kelly, 2002), so this raised further doubt as to whether he is the strangler. Some of the families of the remaining victims are fighting attemtps to exhume any more bodies for fear of bringing up bad memories of the crimes. But a comparison test of the DNA evidence from each victim could help determine whether there was more than one strangler, and it could also determine whether the DNA profile is a familial match to anyone in the Nassar family.

Anastasia

In 1917, Tsar Nicholas II of Russia, his wife Tsarina Alexandra, and their five children Tatiana, Maria, Alexi, Olga, and Anastasia were all taken captive by the Bolshevik party during the Great Russian Revolution. The Tsar and his family were being held in the Ipatiev house in Siberia until they were executed in 1918 by a firing squad. The Family was rounded up by the guards and taken into the basement and shot. It was rumored that due to all the jewels the women had been hiding under their clothing, many of the bullets fired at them ricocheted and flew around the room. The bodies were then buried in a secret place *(Anastasia, 2003; Mystery Files, 2008).*

Roughly two years after the killing of the Tsar and his family, a woman in Berlin, Germany attempted to kill herself and was sent into a mental institution to be watched. While there she claimed to be Anastasia, the Tsar's youngest daughter who had escaped execution. After she was released from the mental institution, she still proclaimed to be Anastasia, and filed a claim to her royal heritage and wanted recognition by society. She claimed to have adopted the name Anna Anderson because no one believed her to be Anastasia. But surprisingly, Anderson had many physical characteristics that matched Anastasia such as her hair and eye color. She also had some similar distinctive body markings including a deformed foot in common with Anastasia. A few of the Tsar's relatives also visited her, claiming she could indeed be Anastasia.

The German Courts decided to investigate this matter, and for the next 20 years or so examined a large variety of evidence to determine if she was telling the truth or lying. They looked to see if Anna had similar facial features as Anastasia or if they had similar handwriting. But in the end the courts found that this evidence was inconclusive and refused to acknowledge

Anna's claim. They had slowly come to believe she might be a missing factory worker Franziska Schankowska, but they could never prove it. In 1968, Anna eventually moved to Virginia where she was married, but she never stopped telling people she was Anastasia all the way to her death in 1984 *(Welch, 2007; Atchison, 2008; Mystery Files, 2008).*

In 1991, American scientists were invited to Russia to help excavate a burial site in Siberia and examine the remains. After forensic anthropologists sifted through the remains, it was determined that nine bodies had been buried here. According witnesses of the the Tsar family execution, it was believed that eleven people had been shot that day: Tsar Nicholas II, his wife and five children, a doctor, nurse, and 2 servants. This meant two bodies were missing from the burial site, and could mean that Anastasia was never really killed *(Mystery Files, 2008).*

Some of the bones did provide some DNA evidence that could help identify the victims. Because the bones were so old, the scientists decided to perform a mitochondrial DNA analysis, which has a higher chance of working on old DNA. Mitochondrial DNA is maternally inherited, so it might provide some clues on relatedness. The DNA showed that one skeleton was the Tsarina, and three other skeletons were her children. Due to the approximate age of the deceased determined from the bones, the skeletons were not of any young women, nor was a male, so those skeletons must be the Tsarina and her three oldest daughters. The Tsar's skeleton was also identified in a similar way, establishing that a set of bones had the correct amount of wear to correlate with his exact age, and the mitochondrial DNA was a familial match to a maternal relative of his, the Duke of Fife. Thus, at this burial site, scientists found the bones of Tsar Nicholas II, the Tsarina Alexandra, and the three eldest daughters Olga, Tatiana, and Maria. So what was missing was the bones of Anastasia and Alexi *(Mystery Files, 2008).*

So maybe Anna Anderson was not lying after all. But scientists wanted to test Anna's DNA. To make the analysis more conclusive than matching the old DNA of the Tsarina, they wanted to compare Anna's DNA to a known living relative. They found that Prince Philip of England shared a Maternal Grandmother with Anastasia, which meant they should both have the same mitochondrial DNA. Since Anderson had died, they needed to find some of her DNA to test. Anderson had an intestinal surgery earlier in her life in Virginia, and luckily the hospital still had a tissue sample at the hospital. Scientists also wanted to compare Anna's DNA to the missing factory worker the German government believed her to be, so they found a relative of Franziska Schanzkowska, Carl Maucher, and requested some of his DNA. Once the scientists had collected their samples from Maucher, Anderson's hospital tissue, and Prince Philip, they ran the DNA profiling in 2007. What they found was that Anna Anderson was actually the missing factory worker, Franziska Schanzkowska, so it was finally settled that Anderson was not really Anastasia *(Kurth, 2003; Science Daily, 2009; Anna Anderson, 2011).*

It remained a mystery where Anastasia's remains were buried until later in 2007 when the two bodies that had been found in the Ural Mountains came back as DNA matches to DNA taken from Prince Philip. Professor Evgeny Rogaev and his colleagues performed mitochondrial DNA and nuclear DNA profiling on the new remains, and concluded that the nuclear markers matched the DNA of Tsar Nicholas II, thus confirming that these were actually the bodies of Alexi and Anastasia *(Science Daily, 2009).*

The Green River Killer (Gary Ridgway)

In the the 1980's and 1990's, the state of Washington had a serial killer picking up women and killing them. The Green River killer, as he became known because he dumped his

early bodies there, would strangle his victims, who were usually prostitutes and then dump them in different areas in King County. The killer eventually admitted to killing 71 women, even though police think he actually killed more than 90.

His first victim was a 16 year old girl Wendy Coffield who was killed on July 8th, 1982. Her body was later found on July 15. On September 25th, the body of 17 year old Gisele Loworn was located after her being reported missing in July of 1982. But the Green River killer wasn't done there. He murdered three more women, Marcia Chapman age 21, Cynthia Hinds age17, and then Opal Mills age 16. He had dumped all these bodies in the Green River. All of these victims were strangled either by hand or by using a ligature (Maleng, 2003; Green River, 2010).

In 1984, the police found a suspect, Gary Ridgway, who was well known to hate prostitutes. Ridgeway was arrested a few times before this for soliciting prostitution, and the police became generally aware of his dislike for prostitutes. The police made Ridgway take a polygraph test which he passed in 1984, but they were not able to get any other evidence against him. In April 1987, the police obtained some hair and saliva samples for DNA evidence. In March 2001, police processed vaginal swabs from several of the victims and also a few hairs found on another victim. The police found that the DNA from the hair and vaginal swabs matched Ridgeway's DNA. Surprisingly, Ridgway was picked up before police knew of the DNA match, by an undercover police officer pretending to be a prostitute. Apparently Ridgway did not want his wife to know he had been caught with a prostitute, so he told the officers to contact the Green River Killer task force and have them come get him. Police ended up offering him a plea bargain to help discover the location of all the missing bodies. He eventually admitted to killing 71 victims between 1982 and 1984. He stated he would drive up and down Route 99, on the Pacific Highway, and look for his victims. Once he found his victim, he would

pick them up, kill them, and strip them naked. Some bodies he would dump in the river, and others he would hide in the woods. He was sentenced to life in prison instead of getting a lethal injection for giving up the locations of all the bodies (Maleng, 2003).

Chapter-4 References

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Chapter-5: DNA Databases

Nicholas Vaughn

Introduction

The traditional evidence collected at a crime scene includes fingerprints, items of clothing, hair, or other personal items linking a person to a crime. But with the rise in DNA technology in the last twenty years, police officers and members of the judicial system have gained a new weapon in the fight against crime. DNA technology has allowed something as small as a hair follicle, drop of blood, or any other bodily fluid to directly link a specific person to a crime scene. This means that a suspect can have their DNA taken and directly matched to that left at a crime scene if they are guilty.

Following the advent of DNA technology for forensics, the Federal Bureau of Investigation and other local agencies created a DNA database of profiles collected from previous offenders and profiles collected from crime scene evidence. Law enforcement agencies submit suspect's DNA profiles into the FBI's Combined DNA Index System (CODIS) to attempt to find a match. This database has proved to be an amazing tool in the fight against crime, helping identify criminals that are repeat offenders. However, DNA databases are controversial. Whose DNA should be included in them? How are privacy rights protected? Some people believe that individuals who commit a crime should not be forced to enter their DNA into the database. Many people confuse the CODIS law enforcement database with medical DNA databases that contain medical predisposition information. This train of thought has sparked an ethical debate that this chapter will investigate and explain.

Databases Help Convict the Guilty

Criminal justice is a field that has grown greatly in the past twenty years. The advancements that have been made in DNA technology have not only created jobs in the field of forensic science and crime scene investigation, they have allowed a much more efficient and concrete way to match criminals to the crimes they commit. This technology relies on CODIS and its ability to match the DNA left at crime scenes to DNA stored offender profiles. However, if a crime is committed by a person whose DNA has not previously been recorded, there is no way of identifying the individual; although scientists can still answer other important questions such as linking two or more crime scenes to each other, even if the perpetrator is not known. Criminals must have previously had their DNA entered into the system for CODIS to be the most effective. This new technology has not only allowed law enforcement to solve current cases, but has helped solve past cases where DNA has been isolated from old stored crime scene evidence.

Exonerating the Falsely Accused

CODIS can also be used to exonerate the innocent. Newly funded programs have been put in place to test whether imprisoned individuals who still claim their innocence have been falsely imprisoned. These programs are only possible because of this new technology in DNA science that has occurred in the last twenty years. "The Innocence Project is a national litigation and public policy organization dedicated to exonerating wrongfully convicted individuals through DNA testing and reforming the criminal justice system to prevent future injustice" (InnocenceProject.org, 2009).

A specific case in which DNA testing was used to free a wrongfully accused man is the case of Kenneth Ireland who "spent 21 years behind bars for a rape he did not commit" (Pierce,

2009). In 1988, Kenneth was tried and was found guilty of rape and murder in the state of Connecticut. In 2009, he returned to court where he presented DNA evidence that showed his profile did not match that from the crime scene, so the charges of rape and murder were dropped and he was set free. This case not only exposed the judicial system for wrongfully imprisoning this husband and father, but showed that DNA databases can not only put guilty people behind bars, they can free the wrongfully imprisoned. "He always claimed he was innocent, and the Connecticut Innocence Project took on his case. Fortunately for Ireland, DNA evidence from the original crime was kept in a state that preserved the DNA. The new DNA technology allowed authorities to re-test the evidence and they found there was no way Ireland could have killed Pelkey" (Pierce, 2009). Cases like Mr. Ireland's show the great uses for DNA databases, and help advocate for their use in this country.

In some cases, two individual's DNAs are similar enough to provide similar profiles that can result in false imprisonment (Brenner, 2004). If the DNA at a crime scene matches a database entry, that is often enough evidence to convict a person of a crime. DNA is often not the only evidence used against offenders, but it is one of the strongest forms of evidence. An accidental and wrongful imprisonment based off of a misleading DNA profile is very rare. However due to advances in technology, the number of false imprisonments has greatly decreased. For example, when a DNA analysis includes the current 13 core loci recommended for entering a sample into CODIS, the probability of a random match to another individual is only one in one hundred billion or 10^8 (Brenner, 2004).

Scientific Uses of Medical DNA Databases

The public often confuses law enforcement databases like CODIS with medical databases that scientists use to help find genes related to specific disorders. Each type of database comes

with a very different set of ethics and concerns. For medical databases, the study of humans' DNA and the creation of DNA databases have more uses than simply aiding in the imprisonment of guilty parties and freeing the wrongfully accused. New leaps in DNA technology have been used to find cures for inherited diseases that are discovered in the analysis of our DNA. Through the study of DNA, scientists have found patterns that exist in some diseases that are passed down through our genetics. Diseases such as early-onset Alzheimer's disease have already been mapped to specific genes, and have helped identify targets for therapy. For Alzheimer's, these genes are APP, Apo-E4, Presenilin-1 (PS1), and Presenilin-2 (PS2). By studying human genetics, scientists can demonstrate that the presence of one or more of these genes increase susceptibility to Alzheimer's. Without analyzing human DNA, scientists cannot learn how our DNA and its genes affect us (Adams, 2000).

However, medical databases come with strong ethical concerns about privacy rights, because these databases, unlike CODIS, contain medical predisposition data that if linked to an individual could lead insurers to deny them health insurance or life insurance. So individuals contributing to this type of database should do so only with informed consent.

Ethics, Civil, and Privacy Rights

When focusing only on solving crimes, many people believe that DNA samples should be taken from every person at birth to create what would be in essence a perfect database to help the fight against crime. This could be done quite easily by swabbing the cheeks of every infant born in this country and anyone who applies and is accepted for citizenship in this country. However, doing so would mean that innocent people would have their DNA profile entered into CODIS, not just previous offenders; and what about *arrested* individuals, should they contribute their

DNA? Thus, the question of who, if anyone, should be forced to enter their DNA into a database is important, along with *what* information should be entered in the database.

Currently, in the United States, individual states determine whose DNA should be entered into CODIS. Some states believe that the more DNA profiles that exist in their system, the more likely they will solve crimes. Other states believe the crimes that require samples to be taken should be restricted to violent crimes. For example, the only state that does not require all convicted felons to give DNA samples is Kentucky. **Table-I** shows that Kentucky only requires DNA samples from "those convicted of unlawful transactions with a minor, promoting sexual performance of a minor, Burglary I and II, and Class A and B felonies involving death or serious injury to the victim." Massachusetts requires all convicted felons and some juveniles to provide DNA. Table-I shows how laws pertaining to DNA profiles differ from state to state, and gives better understanding to how different states feel about DNA profiling.

Table-I. Individual States and CODIS Entries. (National Conference, 2005)

State	All Felonies	Some Juveniles	Some Misdemeanors	Some Arrestees	Not Guilty By Mental Defect or GBMI	Other
Alabama	X					
Alaska	X	X		X -- Violent felonies.		
Arizona	X	X		X -- Many serious felonies.		Includes residential and criminal burglary.
Arkansas	X	X -- Violent crimes only.	X -- Some sexual offenses.		X	
California	X	X		X -- Expansion to all felon arrestees		Includes those convicted of terrorist activity in violation of

				starts in 2009.		weapons of mass destruction provisions; and those convicted of a qualifying offense in another state.
Colorado	X	X				Includes any person who has a duty to register as a sex offender, including probationers, habitual offenders as condition of parole, and those released without parole supervision.
Connecticut	X				X	Includes persons on probation or parole prior to discharge from supervision.
Delaware	X		X -- Certain child endangerment or abandonment crimes.			
Florida	X	X			X	Includes persons on probation, parole, release or supervision following conviction of certain offenses.
Georgia	X	X				Includes probationers convicted of qualifying offense.
Hawaii	X	X			X	Includes qualifying persons in prison, on probation or parole, parole violators.
Idaho		X				Most felons are included.
Illinois	X	X	X -- Any person required to register as a sex offender, includes some misdemeanors.			Includes people held under civil commitment law, those found guilty but mentally ill for a sex offense, persons seeking transfer to state under interstate compact,

						stalking and residential burglary.
Indiana	X					Includes qualifying offenders on probation or parole.
Iowa	X	X	X Any person required to register as a sex offender. Any criminal offenses against minors included.		X	Includes qualifying parolees and offenders on work release and offenders receiving a deferred judgment of felony.
Kansas	X	X		X -- Felony or drug grid level 1 or 2; expands after June 30, 2008 to include all persons arrested for a felony.		
Kentucky		X				Includes those convicted of unlawful transaction with a minor, promoting sexual performance of a minor, Burglary I and II and Class A and B felonies involving death or serious injury to the victim.
Louisiana	X	X		X --If funds authorized.		
Maine	X	X	(May include a lesser included offense if a qualifying offense was originally charged.)			Includes all Class A, B, C serious crimes and Class D and E convictions if the person had prior felony conviction for which DNA not collected.
Maryland	X	X	X	X -- Violent crimes, burglary and breaking and		

				entering of a motor vehicle.		
Massachusetts	X	X				
Michigan	X	X		X -- Violent felonies.		
Minnesota	X	X	(May include offenses "arising out of same set of circumstances.")	X -- Specified serious crimes upon judicial finding of probable cause.		
Mississippi	X					
Missouri	X					
Montana	X	X				
Nebraska						
Nevada	X		X -- Failure to register as a convicted person.			
New Hampshire		X				Includes violent crimes.
New Jersey	X	X	X -- Any crime for which a sentence of imprisonment of 6 months or more is imposed.		X	
New Mexico	X	X		X -- Specific violent felonies.		
New York	X		X -- Many misdemeanors.			
North Carolina	X				X	Includes persons on community supervision.
North Dakota	X			X -- All felonies – effective 01/09.		Many serious felonies, including burglary.

Ohio	X	X	X -- Certain child victim offenses.			
Oklahoma	X					2001 law requires planning to incrementally add qualifying felonies to the database, to include all felony offenses by 2006.
Oregon	X	X				
Pennsylvania		X				Includes violent and sexual offenders.
Rhode Island	X					
South Carolina	X	X	(May be required by court order for any offense.)	X -- Violent felonies punishable by more than 5 years in prison.		Includes qualifying offenders on community supervision.
South Dakota	X	X		X -- Violent felonies punishable by more than 5 years in prison.		
Tennessee	X	X		X -- Violent felonies, upon finding of probable cause.		Includes those persons seeking transfer to the state under interstate compact who have committed qualifying offense.
Texas	X	X	(May be required by court order for any offense.)	X -- Post-indictment only in certain sex crimes.		Expanding to all felons contingent upon federal funds.
Utah	X	X	X -- Class A misdemeanors. Others may qualify if convicted on lower degree of qualifying offense.		X	Includes persons convicted in another state of a qualifying offense.

Vermont	X		(Only if as part of a plea agreement.)			
Virginia	X	X		X -- Violent felonies, including attempts.		
Washington	X	X				Includes those who have been convicted out of state or under federal law of a violent offense.
West Virginia	X					
Wisconsin	X	X	X -- Some misdemeanors for which sex offender registration is required.		X	
Wyoming	X	X				Includes all persons required to register as a sex offender.

As of August 2011, there were over 9,043,732 combined profiles for all state databases combined. New Hampshire had the smallest number of profiles on record with 3,753, and California had the largest number of profiles in their database with 1,360,993 (FBI.gov, 2011). These numbers are drastically different not only due to population size but the way the states feel about DNA databases and their infringement on citizens' constitutional rights.

One of the more heated topics comes from the question, should individuals who are *arrested* and detained but never convicted be forced to give DNA samples? Many people see this as an infringement of the right we have as individuals, as we are supposed to be innocent until proven guilty. Others view this process as a simple extension of law enforcement officers currently taking an individual's traditional fingerprints following *arrests* such as driving under the influence (DUI). Others feel that by taking DNA samples before a court proves guilt, the

government is treating its citizens as if they are criminals before they stand trial. “The FBI has been promoting the [genetic screening] of criminals to establish state DNA identification data banks to be used in criminal investigations; indeed, Federal legislation penalizes states fiscally if they don’t participate, and now all do. Yet the data includes samples from those whose crimes have low recidivism rates or don’t leave tissue samples; in some states people merely accused are forced into the program, and in others there are politicians calling for an expansion along these lines, despite the Constitutional presumption of innocence” (Bereano, 2000). In this particular case, it is important to distinguish from an individual being forced to contribute to a medical database (where the DNA entry could be used to derive medical information) versus an individual being forced to contribute to CODIS (where the DNA entry does not contain any medical information, and is only used for identification purposes). As discussed in detail in Chapter-1, the information entered into CODIS is only for the 13 core loci, which are not locations that map to any known medical predispositions.

Another heated issue that arises from the action of the government to take DNA samples from individuals who committed crimes before DNA databases existed, although these criminals would have been entered into a DNA database if the technologies had been in place at the time they committed the crime. Some believe this action shows a large lack of trust in its own rehabilitation system. In San Francisco, a lawsuit was filed against the state challenging Proposition 69. Proposition 69 required DNA submissions in the two cases discussed in this section (arrestees and detainees, and post-expiration cases). This lawsuit was filed by the American Civil Liberties Union who stated that "California has the most draconian DNA database system in the country because of Proposition 69," said ACLU attorney Julia Harumi Mass. "We are seeking an injunction against the testing, analysis and indefinite storage of DNA

from our clients and Californians like them. We are asking the federal court to protect our fundamental rights to be secure from unconstitutional police searches and to privacy in our personal medical and genetic information." "People who may be subject to DNA testing under the law, despite being innocent of any crime, include victims of identity theft, victims of police misconduct, political protesters, and lawful medical marijuana users. Proposition 69 also mandates the sharing of DNA samples with law enforcement and private laboratories nationwide and globally" (ACLU, 2004). "Others caught in the DNA dragnet include: victims of domestic violence, who are arrested for violence committed in self-defense and who either have the charges against them dropped or are subsequently acquitted; and people who were arrested for felony drug offenses and who upon successful completion of treatment programs, have had their convictions expunged under Proposition 36 or other state laws. The ACLU clients in the case include people who fall into those categories" (ACLU Challenges….2004).

Although no one has ever been forced to give samples of their DNA if they have never been arrested or detained, the debate about to what extend the government has the right to require DNA samples from people who have done nothing wrong still continues.

When discussing the ACLU debate, it is not only important to distinguish what information is entered in the database, but also whether the *original* DNA sample has been destroyed. Although CODIS contains no medical information from the DNA sample, if the original DNA sample itself resides in a freezer, it could be analyzed beyond CODIS information to indeed determine medical predisposition information. Thus, it is important to mandate the original DNA sample be destroyed following DNA analysis. Though some people disagree with the government forcing criminals to enter their DNA into databases stating that it violates their civil rights and is a violation of privacy, there is no question that the CODIS database has done a

great deal of good in our society. Law enforcement officials have stated that the database has helped put thousands of people behind bars and free at least 200 wrongfully convicted individuals (Moore, 2009).

Medical Predispositions

The access to information about out medical predispositions should most certainly be kept private. The ACLU warns citizens of the consequences that could arise from the creation of DNA databases (we assume they mean medical databases not CODIS): "It opens a genetic window that reveals intimate information about you and your family including predispositions to Alzheimer's disease, depression, multiple sclerosis, and cancer. Law enforcement should not be allowed to seize that personal, private information when you haven't even been charged with a crime" (ACLU Challenges….2004). The real fear is that [medical] DNA databases could somehow be hacked or infiltrated allowing anyone access to personal information that could have very extreme consequences. It is unclear as to why the ACLU in the above statement believes that law enforcement (that oversees CODIS) would have any interest in medical databases. So we believe that the ACLU is confusing the public about the key difference between law enforcement DNA databases and medical databases.

The Health Insurance Portability and Accountability Act, limits genetic discrimination as a basis for denying certain insurance medical insurance policies, but it does not prohibit charging higher premiums, nor does it cover life, disability, or automobile insurance or to employment — all areas of documented discrimination (Bereano, 2000).

Other Ethical Concerns

Imprisonment for crimes committed in this country is supposed to be a way of reforming citizens who have acted in an ill manner. Many believe that the creation of these databases disvalues the concept that prison is supposed to be used for rehabilitation. If DNA is going to be taken from every criminal to help catch them again if the individual commits another crime than, that action disvalues the system's ability to rehabilitate prisoners in the first place. This is a valid point, but history has shown those criminals are indeed often repeat offenders, so even if it devalues the system's attempt at rehabilitation, it should still be used. The problem is not that we are archiving their DNA to stop repeat offences, the problem is that our rehabilitation system is not working, and this helps solve crimes. If the individual who archived his DNA does not commit another crime, no harm has been done archiving the profile. The archiving does not disvalue the good that CODIS brings in solving cases of often heinous crimes. Once a person commits a crime that warrants storage of their DNA in a criminal database, they give up their right to withhold the CODIS identifying information from society, but they do not give up the right to withhold their medical information.

Chapter-5 Conclusions

Thus, overall the DNA database debate should consider what type of information is actually entered into CODIS. The 13 loci that are used to identify those entered into DNA databases have no way of revealing any medical predispositions. That is the reason those specific loci were chosen. Although people fear that their family's genetic information could be stolen or leaked from a database, they should have no fear of that from a law enforcement database. By

simply destroying the DNA sample used to identify the 13 loci for DNA identification, access to a person's full range of genetic material and medical predispositions becomes impossible.

There is no doubt that government officials should provide strong oversight and supervision in the creation of both types of DNA databases. DNA databases are a relatively new technology, and because of this, it is not outrageous to question the power and possible downfalls these technological processes. Ethical debates are almost certainly going to arise when it comes to issues such as DNA archiving, however the construction of DNA databases such as CODIS is not in violation of our constitutional rights. There is no way that medical predispositions could be revealed by the hacking of CODIS or the leaking of the information in it. However there still is no law forcing the destruction of samples used to locate the 13 core loci used for identification. A law should be made so that samples are destroyed as soon as the 13 core loci are identified and stored in the system. That way even if information concerning the 13 core loci used for identification, which cannot produce any information concerning a person's medical predispositions, the rest of the information in a person's DNA sample cannot be revealed.

In regards to the ethics of the creation of these databases and who should be entered into them. It is clear that the databases do much more good than harm. If a person commits an act that warrants an action such as the storage of his or her DNA profile in a criminal database, then the criminal relinquishes his right to keep that identifying information privacy for the betterment of society, but does not give up his right to *medical* privacy. Whether it is right to force those arrested and not convicted to give DNA samples to a criminal database is still up for debate. That question will not be answered in this paper, it is up to the people who reside in states such as

California to inform themselves and their communities of the laws of their state, and work to change them as they see fit.

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PROJECT CONCLUSIONS

Deoxyribonucleic acid (DNA) is the chemical responsible for biological characteristics. DNA is in essence a set of genetic instructions needed for our cells to function. All human DNA is 99.9% identical; however that small portion that differs between individuals can be used for identification purposes. DNA fingerprinting is a powerful tool for forensic scientists and those in the field of criminal justice. The use of this tool in comparing crime scenes, or studying and matching suspects to crimes, is matched by no other technology. DNA fingerprinting can also be used to identify the bodies of soldiers who made the ultimate sacrifice for our country.

DNA profiling analyzes repeat sequences in human DNA known as variable number of tandem repeats (VNTRs) or short tandem repeats (STR). The techniques used to analyze the repeats are non-amplifying RFLP-like techniques that are often used when sufficient quantities of DNA sample are available, or polymerase chain reaction (PCR) which is often used when low quantities of DNA sample are available. Because STRs are relatively short, they can rapidly be amplified by PCR, so STR-PCR techniques are currently the most commonly used. However, STR-PCR is prone to contamination, so RFLP techniques are sometimes used to supplement the STR-PCR information when sufficient quantities of DNA are available.

DNA profiling and forensics is the most powerful tool that law enforcement officials have. Because of this, it is vital that the first responder to a crime scene is trained in the proper methods for controlling a crime scene, and collecting and storing DNA evidence. Improper collection of evidence can lead to DNA degradation or contamination. Every DNA sample has a chain of custody to ensure that the sample was property handled and by whom.

DNA Fingerprinting technology is regarded as the greatest tool in the history of forensic science, however it acceptance into the United States court system has not been simple or clear cut. New technologies often face opposition due to a lack of technical understanding and legal precedence. Since 1988, when DNA forensic technology was first put to use in the United States, various landmark cases have set legal precedence for admitting technical information in courts. The current *Two Bulls* standard for admitting evidence includes a rigorous five-prong test devised from several prior cases that includes determining 1) whether DNA testing is general accepted in the scientific community, 2) whether the testing procedures used in a particular case are generally accepted and reliable if performed properly, 3) whether the DNA testing was performed properly in this case, 4) whether the DNA evidence is more prejudicial than probative, and 5) whether the statistics used to determine a match is more prejudicial than probative.

These landmark cases often are unfamiliar to most people, and instead various sensational cases, such as the Boston Strangler or the OJ Simpson trial display this great technology to the layperson. In the case of the Boston Strangler, DNA evidence was used 30 years after the crime to prove that a man who claimed to be the serial killer and rapist did not commit the crime. In the OJ Simpson trials, there was a multitude of DNA evidence linking OJ to the crime scene; however improper care of the evidence led to potential contamination, making the DNA evidence against OJ worthless in court. As a result of this trial, law enforcement tightened its policies and trained more professionals to properly collect and store DNA samples, ensuring that evidence is tightly controlled and handled only by trained individuals. These policies help to ensure that vital evidence is not contaminated or degraded before the prosecution can use it.

Ethical debates are almost guaranteed to arise whenever new technologies such as DNA fingerprinting are discovered. Even though DNA databases and DNA fingerprinting are powerful tools for helping law enforcement, debates concerning the use of this technology are still being carried out. Many of the debates result from mis-information. The public is often unaware of the key differences between medical databases (that can contain medical predisposition information and are maintained by geneticists) versus CODIS (which contains only identification information not medical information, and is maintained by law enforcement). DNA fingerprinting for law enforcement targets 13 core loci that have been carefully selected to not divulge any information concerning a person's medical predispositions. However, the original DNA sample could be further analyzed to obtain medical information, so a law should be passed to mandate that all DNA samples should be destroyed after the 13 loci are recorded in the database, ensuring that the DNA samples cannot fall into the wrong hands.

Who should be forced to enter their DNA into CODIS is a debate that continues to this day. In the US, whose DNA is entered into CODIS is decided by individual states, not the federal government. It is the belief of the authors that if one commits a malicious crime or felony, then they should lose their right to privacy and have to enter their DNA into the system. If someone breaks the law, they infringe on the freedoms of other individuals, thus that person should be forced to enter his or her sample into CODIS to help convict them if they choose to commit another crime, or simply to deter them from breaking the law again. There is no doubt that the discovery of DNA technology and DNA databases have done more good for society than harm. They are the most powerful tools forensic scientists and law enforcement have to incarcerate individuals guilty of crimes or to exonerate the innocent.