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DNA FINGERPRINTING

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ABSTRACT

DNA fingerprinting has had tremendous effects on society. This IQP explains the main methods for performing DNA fingerprints, and proper procedures to be taken while collecting and storing DNA samples. It also examines landmark DNA court cases, describing the journey DNA fingerprinting has made through our court system to set precedences for providing viable evidence. Sensational court cases were also analyzed to show the effectiveness of using DNA technology. The ethics behind DNA databases is also examined, and author conclusions are drawn.

TABLE OF CONTENTS

PROJECT OBJECTIVES

This project was undertaken to examine the technology of DNA fingerprinting, and document its impact on society through legal issues and ethical debates over databases and the use of the technology for scientific advantages. The purpose of chapter-1 is to discuss the main applications and main ways profiles are obtained. Chapter-2 covers proper collection and storage. Chapter-3 investigates landmark courtcases to uncover how court procedures for allowing DNA as evidence have changed over the years. Chapter-4 describes some sensational DNA cases to help illustrate the power of DNA technology, even for crimes that are decades old. Chapter-5 investigates the use of DNA databases for scientific advancement and for crime solving, while also revealing key ethical issues. Finally, the authors of this IQP make conclusions about this controversial powerful technology based on their research.

CHAPTER-1: DNA FINGERPRINTING TECHNOLOGY

Christopher Butcher

Deoxyribonucleic acid (DNA) is the material in almost all organisms, including humans, which contains the genetic instructions for biological development. The sequence of its main components specifies the information needed to make us all human. Although our DNAs are about 99.9% identical, distinguishing us from other species, forensic scientists are interested in that small portion that makes us unique. DNA fingerprinting technology allows the differences between individual DNAs to be determined, providing forensic scientists with an amazing tool for comparing crime scene DNA with suspects, allowing scientists to study human migrations and evolution, and allowing the military to identify unknown remains. The purpose of this chapter is to introduce this topic, discussing its main applications and the main ways the profiles are obtained.

DNA

The sequence of DNA is determined by the order of four chemical bases: adenine (A), cytosine (C), guanine (G), and thymine (T). Human DNA contains roughly 3 billion of these bases, 99 percent of which are identical in all humans (Genetics Home Reference Handbook, 2009). DNA is not limited to one location. A large percentage of DNA is found in the cell nucleus (nuclear DNA), while the rest is in the mitochondria (mitochondrial DNA). Nuclear DNA is analyzed most often in crime scene applications, while mitochondrial DNA is usually analyzed in evolution and migration studies.

DNA is arranged into a double helix (**Figure-1**), a spiral structure created by the combination of two nucleotide strands. DNA bases pair with each other (shown as colors in the figure) to form base pairs: adenine with thymine, and guanine with cytosine. The chains are composed of a backbone composed of phosphate and sugar residues.

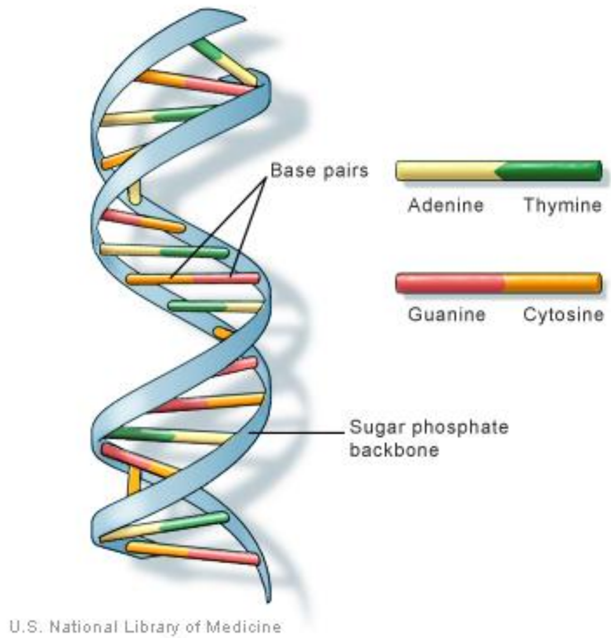

Figure-1: Diagram of the Double Helical Structure of DNA. The four types of bases whose order represents the DNA sequence are shown as different colored rungs of the ladder. (Genetics Home Reference Handbook, 2009)

DNA is created in humans through the combination of the genetic material of your mother and father formed during reproduction, resulting in a unique DNA sequence. Although the DNA in siblings was formed from the same parental genetic material, the combination of the material is always different (except for identical twins), resulting in a different nucleotide sequence for every individual. DNA is expressed into protein within a cell to allow the cell to perform properly. For example, Melanocytes decode the DNA information to produce melanin pigment that gives color to skin and hair.

As DNA gets passed between generations, so also do the genes for hereditary diseases such as autism, multiple sclerosis, and a disposition to certain health factors including obesity and heart disease. So this raises the question as to whether this type of medical predisposition information exists in DNA databases, which will be addressed in Chapter-3. Due to advances in science and technology, scientists can sometimes make predictions about the likelihood of a person being predisposed to specific illnesses.

Chromosomes

Inside our cells, nuclear DNA exists in chromosomes (**Figure-2**). Chromosomes are DNA combined with proteins to form compact structures which aid DNA replication (The National Health Museum, 2008). A long DNA molecule would have trouble replicating and then separating, but our DNA molecules are wrapped around histone proteins to shorten the DNA into structures capable of separating after replication.

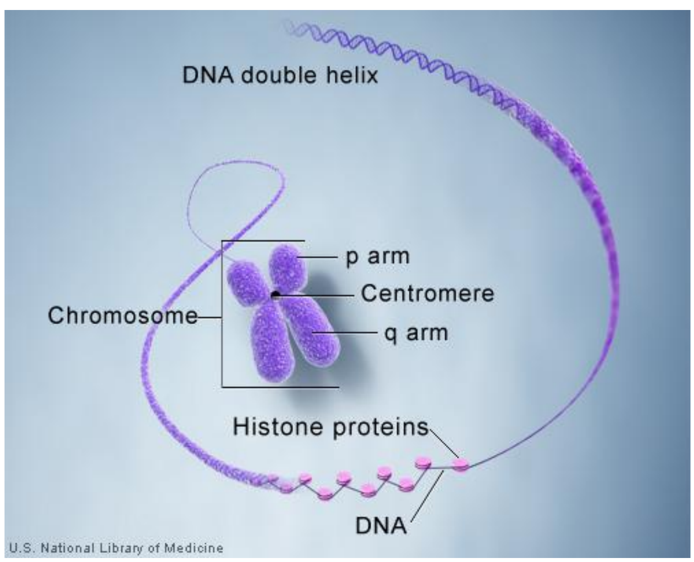

Figure-2: The Chromosome Structure of DNA. Within a cell, DNA exists associated with proteins to form compact structures which can more easily separate following replication. (Genetics Home Reference Handbook, 2009)

There are 23 chromosome pairs in the human body, with each parent contributing one chromosome per pair. One example of a chromosome pair is the twenty third pair, which determines the gender of a person. This chromosome pair is typically X-X or X-Y, with X-X specifying female, and X-Y male. During development, the gender of the fetus is determined solely on the chromosome given by the father, as the only chromosome the mother can give is the X chromosome.

Gene Loci

The genetic information held by chromosomes is usually located in genes, and where these genes are found on chromosomes are known as locations or loci. To maintain biological functionality, most genes are identical in everyone, but there is slight variation in a small number of genes which provide our individuality, and which can be used in DNA profile analysis to help identify individuals. After much genetic research, forensic scientists have identified specific loci that vary greatly between individuals. For the FBI's DNA database CODIS, the standard analysis currently includes 13 core loci. The greater the number of loci analyzed, the less likelihood of an incorrect random match between samples (CODIS, 2004). Scientists can readily assay the differences between two DNA samples by characterizing repeating sequences at key loci. DNA fingerprinting would not have been possible without the ability to identify key loci that vary between individuals.

Applications for DNA Fingerprinting

One common application for DNA fingerprinting is paternity tests. The first DNA paternity test was performed in 1985, where it was proven that a boy, suspected of having a forged passport during his attempt to be with his mother in Great Britain, was actually this woman's biological son. The test also showed that all of her children had the same father (Jeffrey's et al., 1984; The Economist, 2004). Paternity testing does not seek to make an exact match to a DNA fingerprint. DNA is taken from the child and all individuals claiming to be parents. Knowing that the DNA of parents are passed on to their children, scientists can eliminate the fragments of the child's DNA fingerprint with the matching fragments of the known biological parent and compare the fragments that remain with those of the suspected parent. If the fragments match up, then they are the parent of that child.

Paternity testing has come a long way in the last 25 years. "In 2001, US labs alone performed more than 300,000 paternity tests, and many countries have compiled large DNA databases" (The Economist, 2004). While there is a small chance of an incorrect match, scientists and the judicial system alike have confidence in paternity test results, especially when accompanies by other corroborating evidence.

One of the biggest uses for DNA fingerprinting is in forensics, as it greatly assists in helping identifying suspects. Any piece of a person's body could be used to identify that person as DNA exists in most cells in the body. Forensic applications not only help convict the guilty, it helps exonerate the innocent.

DNA fingerprinting has even made an impact on history. Scientists were able to categorize the Dead Sea scrolls based on the material they were written on, allowing them to reconstruct how the scrolls were initially ordered. Scientists have also started "to measure the genetic variation between different populations of a species, determine the geographic distributions of species, help preserve endangered or threatened species, and determine the genetic resilience of wild populations of endangered species" (Biotechnology Industry Org, 2009).

Fingerprinting Technology

DNA fingerprinting or profiling, "is a DNA-based identification system that relies on genetic differences among individuals or organisms. Every living thing (except identical twins, triplets, etc.) is genetically unique. DNA fingerprinting techniques focus on the smallest possible genetic differences that can occur" (Biotechnology Industry Org ,2009) . DNA fingerprinting identifies these differences in short pieces of DNA which repeat. Repeats are often categorized as VNTRs or STRs depending on their overall lengths.

VNTRs

Variable Number of Tandem Repeats (VNTRs) are stretches of genetic repeats that sometimes form during DNA replication and whose lengths vary between individuals. Scientists have devised tests that can reveal the differences in VNTR lengths between samples. For example, **Figure-3** shows a comparison of two individual's DNAs at two loci, locus A and locus B. Individual-1 at locus-A (diagram upper left) shows two lengths of the repeating element AGCT, with five and two repeats present on different chromosomes. Those two VNTRs are visualized as two different bands A5 and A2 in an electrophoretic analysis which separates DNA molecules by size. DNA profiling techniques allow the visualization in the different lengths of these VNTR loci. Typically, the RFLP type analysis (discussed below) is used for VNTRs because they are too long to analyze by the PCR technique.

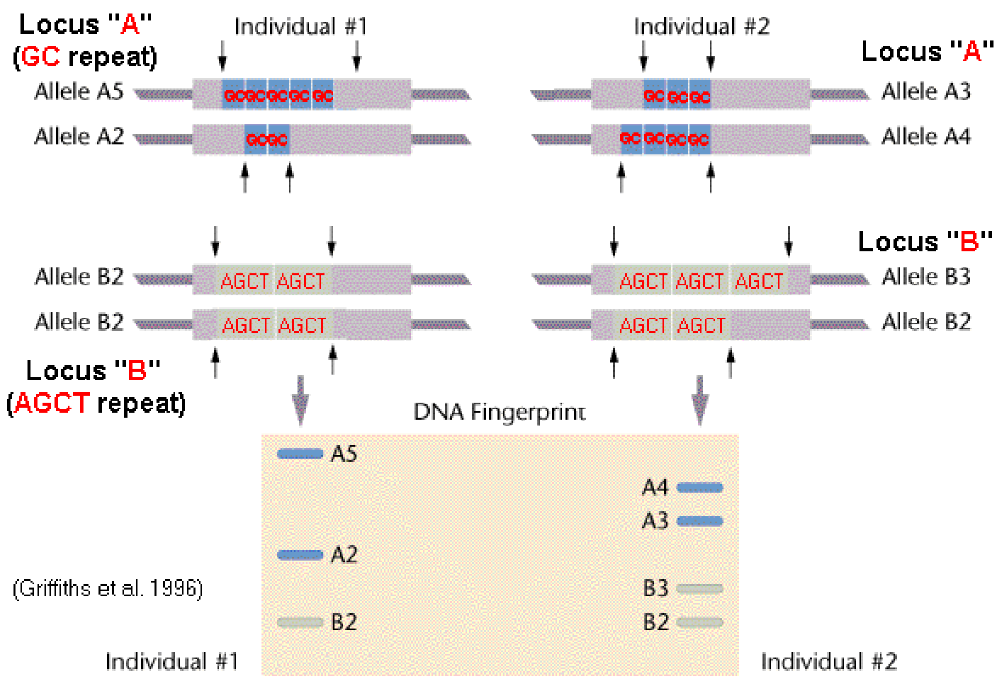

Figure-3: Example VNTR DNA Analysis. The diagram shows a comparison of two individual's DNAs (left side and right side) at two loci A and B. Note how the difference in lengths of the AGCT nucleotide repeats is visualized in different length bands in the gel analysis (lower portion of diagram). (Griffiths et al, 2006)

STRs

Short tandem repeats (STRs) are similar to VNTRs, as their lengths vary between individuals, but they are short enough to be analyzed by PCR technology (discussed below). PCR rapidly amplifies DNA, so STR/PCR analysis has become the most popular testing method since it is rapid, and can be performed on small quantities of DNA, including from a single cell (Butler and Reeder, 2004).

RFLP Analysis

Restriction Fragment Length Polymorphism (RFLP) analysis is a method used by molecular biologists to visualize differences in the lengths of DNA fragments between specific restriction sites. The technique was first applied to forensic analysis in 1984 by Sir Alec Jeffreys (Jeffreys et al., 1984). Restriction enzymes cut DNA at specific sequences excising restriction fragments whose ends contain the recognition sequence. For example, the enzyme EcoRI cuts DNA at sites containing GAATTC. If restriction sites flank repeat loci, such as VNTRs or STRs, cutting the DNA with the enzyme will excise those loci which can then be sized on an electrophoretic gel. Specific DNA fragments are visualized in the gel by blotting the separated DNA fragments to a membrane, that allows a probe to be hybrizized to the fragments of interest. Because the probe is radiolabeled or fluorescently labeled, the bands appear as black on an x-ray film (**Figure-5**). The RFLP technique is somewhat cumbersome, can take a week to perform, and requires a relatively large amount of DNA compared to the PCR technique. Thus, RFLP analysis is used in paternity or criminal cases when sufficient DNA is available (Davidson College, 2001). RFLPs can also be used to identify specific diseases in an individual. The more fragments analyzed from various RFLP sites, the more specific the overall analysis becomes.

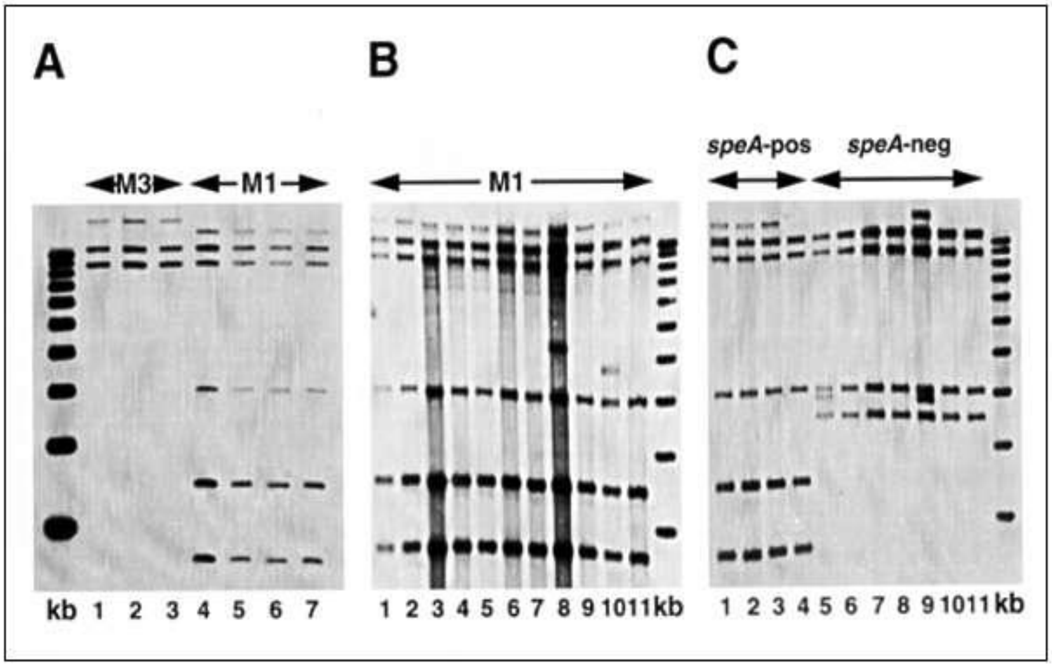

Figure-4: Example of an RFLP Type Fingerprint. Note the appearance of different patterns of dark restriction fragment bands between individials in panels A-C (CDC, 2009)

PCR Analysis

Polymerase Chain Reaction (PCR) is a technique used to amplify the number of copies of a specific region of DNA to produce enough DNA to be adequately tested. The technique was invented by Kary Mullis, who earned a nobel prize in Chemistry in 1993 (Nobel Prize, 2006). The technique is very rapid (it can be performed in hours), and it can be applied to small amounts of DNA, so PCR is usually preferred over RFLP analysis. PCR can be used to identify with a very high-probability, disease-causing viruses and/or bacteria, a deceased person, or a criminal suspect (Brown, 1995).

The first step in performing PCR (**Figure-6**) is to heat the DNA, causing the paired strands to separate (diagram step-1). After the strands split, they are placed into a solution of primers, and cooled (diagram step-2) to allow the primers to hybridize to the DNA strands flanking a locus of interest. The temperature is then raised to about 72ºC the optimum temperature of Taq polymerase which initiates DNA synthesis from the primers. The cycle is repeated from 20-35 times to amplify the DNA locus billions of times (diagram lower). This allows forensic scientists to obtain a much larger sample of DNA to analyze from just a small initial crime scene sample.

The limits of PCR is it is sensitive to contamination, and it can usually only be applied to relatively short loci, such as STRs. But is it rapid, and the STR/PCR approach has become the most popular current method of analysis.

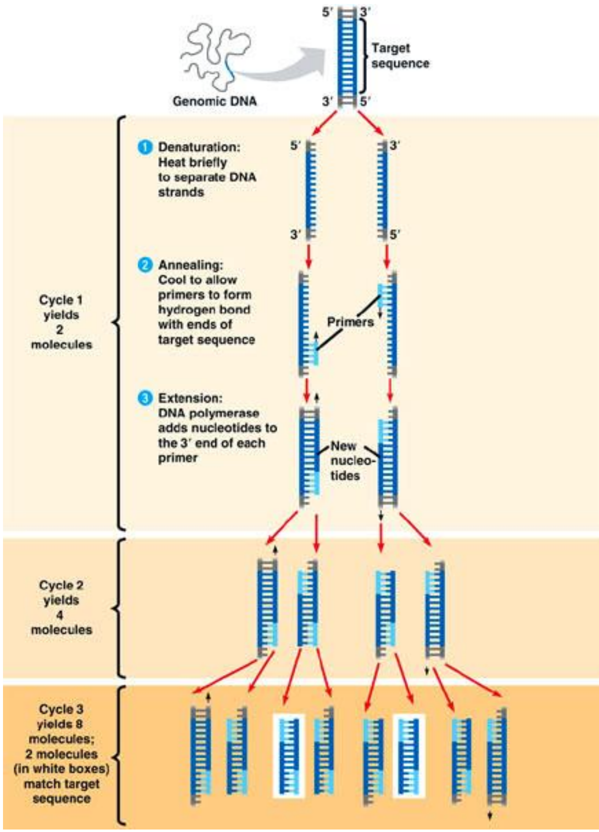

Figure-5: Diagram of PCR Technique for Amplifying DNA. The DNA is heated (step-1) to separate the two strands, then hybridized with primers that flank a locus of interest (step-2). Taq polymerase (a heat stable DNA polymerase enzyme) then uses the primers to initiate new DNA systhesis (step-3). The technique allows the analysis of DNA from very small crime scene samples. (AARANYAK, 2007)

The above explains the two main ways of performing DNA fingerprint analyses. While there are other ways to perform DNA fingerprinting analysis, they all attempt to visualize the genetic fact that every person has their own unique DNA sequence.

Chapter-1 Bibliography

Biotechnology Industry Organization (2009) DNA Fingerprinting: Other Uses. http://www.bio.org/speeches/pubs/er/otheruses.asp

Brown JC (1995) What the Heck is PCR? http://www.people.ku.edu/~jbrown/pcr.html

Butler JM, Reeder DJ (2004) A Brief Introduction to STRs. http://www.cstl.nist.gov/biotech/strbase/intro.htm

CODIS Combined DNA Index System (2004) *Federal Bureau of Investigation.* http://www.fbi.gov/hq/lab/codis/index1.htm

Davidson College (2006) Department of Biology. RFLP Method - Restriction Fragment Length Polymorphism. http://www.bio.davidson.edu/courses/genomics/method/RFLP.html

Genetics Home Reference Handbook (2009) ghr.nlm.nih.gov/handbook/basics/dna

Jeffreys, A J, V Wilson, SL Thein (1985) Individual-specific 'fingerprints' of human DNA. *Nature* **316**: 76-79.

Jeffreys, Alec J., Brookfield J, Semeonoff R (1985) Positive identification of an immigration test-case using human DNA fingerprints. *Nature* **317**: 818-819.

Nobel Prize (2006) The Three Main Temperature Steps of PCR. http://nobelprize.org/chemistry/laureates/1993/illpres/pcr.html

The Economist (2004) DNA's Detective Story. Science Technology Quarterly. http://www.economist.com/displaystory.cfm?story_id=2477036

The National Health Museum (2008) The Structure of DNA Molecule Glossary. http://www.accessexcellence.org/AE/AEC/CC/DNA_glossary.php

CHAPTER-2: DNA FORENSICS

Christopher Butcher

DNA forensics is the most important tool law enforcement has at a crime scene. It is so important that an entire investigation can hinge on the first responders being able to properly secure the scene, identify evidence, and store the evidence correctly to prevent DNA contamination or degradation (Byrd, 2000). The purpose of this chapter is to review some of the proper procedures in DNA forensics, to gain a broad overview of DNA technology.

Securing the Crime Scene

The crime scene should first be secured by establishing a restricted perimeter. This is done by using some type of rope or barrier. The purpose of securing the scene is to restrict evidence contamination or destruction (Byrd, 2000). Law enforcement officers also have to ensure that they themselves do not destroy or contaminate evidence in any way, because only with proper treatment and handling will DNA evidence be admissible in court. Guidelines have been created to teach officers correct forensic procedures, to help ensure they do everything possible to preserve the integrity of the evidence.

DNA Contamination Prevention

The proper collection of evidence is one of the most crucial parts in a police investigation. With respect to DNA evidence, bodily fluids, particularly blood, are the most common forms of DNA evidence found at a crime scene. The location of the stain determines the method in which the stain has to be collected. A stain on a victim’s shirt for instance, would be rather simple to collect and test, but a stain on a rug is usually excised. To guarantee the integrity of the DNA prior to testing, the entire shirt would be placed in an evidence bag that is porous. Plastic bags are usually avoided for collecting evidence containing DNA as moisture leads to DNA degradation (Arrowhead Forensics, 2007). After the bag is labeled, it is brought to a lab for forensic analysis. As long as evidence is properly obtained and packaged, it will be a vital tool that law enforcement can use to solve the case.

There are other methods used to collect DNA evidence. The swab method is used when the original item cannot be collected in its entirety. If someone were to get shot, they would leave a trail of blood on the ground. Since it is impossible to bring the ground to the forensics lab, investigators have to bring the sample safely to the lab. In order to take a swab sample, a cotton tip swab must first be moistened with clean water. After the sample is taken, the swab should then be air dried, with each sample being packaged separately. The sample should avoid direct sunlight at all times, which can degrade DNA (Kramer, 2002). It is also possible to use tape to lift dried blood off of non-porous surfaces. Depending on the stain, you may be able to maintain the shape of it by using the tape method. The “lift” is placed sticky side down on plain white paper, and should then be packaged in an evidence envelope.

Control samples (taken away from the blood stain but on the same material) are needed by forensic analysts so they can compare them to the evidence collected. Analysts need to determine how the two samples differ to ensure results accuracy. The control sample should not show any signs of DNA proving the test solutions themselves are not contaminated. When collecting a control sample, it is suggested that it be taken prior to any other samples, thus lowering the risk of contamination from blood or any other fluid. It is crucial that the same method for obtaining both the control sample and the evidence sample be used, be it a swab or a sample cut-out. Finally, the same process must be used for both samples, all the way down to the water used to dampen the swabs prior to use.

Crime scene investigators themselves have safety attire of their own in order to prevent themselves from contaminating the crime scene. Latex gloves are a necessity for safe crime scene investigation, preventing any contamination from occurring by the hands of the investigator. Investigators must also be concerned about their clothing, refraining from wearing baggy clothes that may get caught on an object at the crime scene. A well-trained investigator should also always have access to a change of clothes, as they never know when they might need to visit a different crime scene. By changing clothes, investigators eliminate the chance of contaminating the evidence of a new crime scene with that of an old crime scene.

Through proper police work, as well as scientific diligence from forensic analysts, more criminals are being put away, and the streets are becoming safer. This is all due to proper evidence collection and the prevention of contamination. With continued police training, investigators should have no trouble collecting clean evidence and putting criminals behind bars. DNA evidence has never been as reliable as it is today, and can easily be the sole factor in whether somebody gets convicted or not.

DNA Evidence Collection

Proper DNA collection at a crime scene is the key to the DNA fingerprint created through analysis being admissible in court. Defense lawyers can have evidence thrown out of court if its collection was compromised in any way, allowing criminals to potentially go free. Local, state, and federal law officials use DNA evidence alike to get convictions, therefore investigators with knowledge on how to properly collect, document, and analyze evidence are an invaluable resource for the prosecution.

The first step in the prevention of faulty evidence collection is training. The only way to prevent mistakes from occurring, which would result in contaminated evidence, is to teach investigators proper techniques for collection. Crime scene investigators are not the only ones who need to be taught either. Patrol officers, to EMT's, as well as any other emergency personnel also need to know proper procedures to eliminate the contamination of any evidence. Preventing contamination starts when the first officer pulls up to a crime scene. If the scene is not secured, particularly by creating a perimeter to prevent unauthorized personnel from entering the scene, then contamination of evidence can easily occur.

Training prevents officers and investigators from not only keeping the scene protected from unauthorized personnel, but also from themselves. A first year officer has been trained in how to secure a crime scene, but that officer knows that is not all that has to be done to prevent evidence from being contaminated. An officer does not aimlessly walk around a crime scene. They know to be cautious not to disturb anything. Allowing investigators to see an unaltered crime scene gives them the best advantage to determine exactly what happened. Guidelines for personnel who may or may not come across a crime scene are very strict, but that strictness is what continues to allow for proper DNA evidence collection and analysis, resulting in the capture of dangerous criminals.

Investigators are faced with a particularly difficult challenge when it comes to older crime scenes, as DNA tissue can quickly deteriorate, preventing DNA from being extracted and tested. It is also hard to guarantee the integrity of evidence at older crime scenes, as the scene could have easily been contaminated by prolonged exposure to the environment or other contaminating factors (Kramer, 2002). “Common sense and knowledge of previously approved practices seem to be the rule when deceased individuals are concerned, particularly when severe decomposition is present and blood work not practical. If hairs are to be submitted, make sure the collector obtains pulled hairs which are more likely to contain intact hair roots and DNA. The tissue associated with the hair root is needed in the DNA analysis. Other samples which may be suitable for DNA analysis include: bones (rib or long bones preferred), teeth, muscle tissue, and associated property which may be found with the body (hairbrush, toothbrush, etc.) (Kramer, 2002).

These “associated properties” talked about by Det. Robert Kramer may very well be the only source of DNA able to be recovered from an older crime scene. Typically, most physical evidence will no longer be present at an aged crime scene given its prolonged exposure to the environment. The crime scene could have been disrupted by people or even animals, causing contamination of what evidence there is. These as well as other contributing factors make the identification of a suspect much harder. That is why the preservation of the evidence that is able to be collected and recorded is crucial when dealing with an older crime scene.

Storage of DNA Evidence

“Because of the sensitive nature of DNA evidence, coupled with the trace amounts that are usually found, the proper collection and handling of DNA is imperative to preserve the evidence without contamination. With DNA evidence databases growing and becoming more successful at getting cold hits on unidentified DNA evidence or exonerating the wrongfully imprisoned, the long-term storage of DNA is becoming something state governments must consider” (NCSC,2003). By continuing to store samples of DNA and constructing databases around such information, state and federal law enforcement agencies will have a larger number of samples to compare against when checking a person’s DNA. This will continue to result in the identification and capture of suspects who’s DNA is being compared to the DNA samples within the databases.

While being stored, DNA samples can degrade over time. Many reasons for DNA degradation are caused by the environment, the most common of which are temperature extremes. Storing DNA at or below room temperature will help to reduce DNA degradation. Many times, samples will be kept slightly above freezing, preventing ice crystals from forming on the sample. Fluid samples, however, are stored below freezing. Controlling the temperature of the samples helps to maintain the integrity of the sample, allowing it to be unaltered from when it was entered into evidence.

Another cause for DNA degradation while being stored is moisture. If a sample is stored with any wetness, it becomes susceptible to bacteria. Investigators and forensic analysts need to prevent the growth of bacteria within a sample, or that sample will be ruined. The bacteria will cause the testing results to be flawed, resulting in the DNA fingerprint to be wrong. Investigators must also be aware of the evidence when it is being packaged at the crime scene. Evidence bags are made out of paper (**Figure-1**) to allow ventilation, and the evidence should be dry before it is placed within the bag.

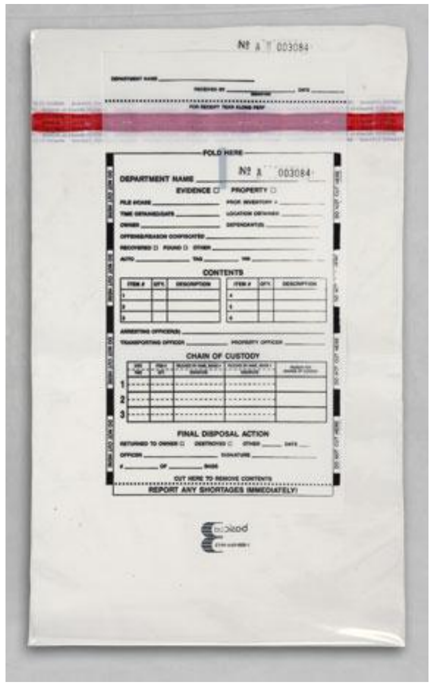

Figure-1: A DNA Evidence Bag. Note that it is paper not plastic to avoid moisture accumulation which can degrade DNA. Also note the extensive bag label which allows key information to be encoded to track the sample and avoid tampering. (Basic Ltd.)

Extreme care must be placed on all aspects of DNA evidence collection and storage. Proper preparation, such as training, greatly decreases the risk of contamination or degradation of the evidence. No matter how careful one is with a DNA sample, it will eventually degrade over time. This places increased importance on the initial lab results, which should be shown the same delicate care as the sample itself. If investigators receive accurate analysis of a DNA sample, those results can still be used as evidence long after the DNA sample was tested, and long after the DNA has degraded. Continued work towards the prevention of DNA evidence contamination or degradation greatly assists in accurate testing and admissibility in court.

Chapter-2 Bibliography

Arrowhead Forensics (2007) Evidence Collection.
http://www.crime-scene.com/ecpi/evidence_collection.shtml

Byrd, Mike (2000) Duty Description for the Crime Scene Investigator.
http://www.crime-scene-investigator.net/dutydescription.html

Kramer, Robert E. (2002) DNA Evidence Collection Principles. Iowa Division, International Association for Identification. http://www.geocities.com/cfpdlab/DNA.htm

National Center for State Courts (2003) Evidence Storage and Handling
http://www.ncsconline.org/WC/CourTopics/overview.asp?topic=StoEvi

Basic Ltd. Figure 1: DNA evidence bag
www.basicltd.com/evidence_property_bags.html

Chapter-3: Landmark DNA Court Cases

Dennis Sullivan

Introduction

DNA fingerprinting technology has been heralded as the greatest tool in the history of forensic science. However, its acceptance as evidence in courts in the United States has not been simple. In fact, the acceptance of any new scientific technology, such as polygraphs, spectroscopy analysis of chemiscls, DNA profiling, etc. as court evidence is not without obstacles because of the lack of legal precedence and a lack of technical understanding of a new concept. Since DNA's first use in U.S. courts in 1988, the guidelines for its use have been rewritten numerous times. This chapter explores some of the landmark cases that led to our current five-prong approach for accepting DNA evidence.

Frye v. U.S. (1923)

Since the 1920's *Frye* Case, its "general acceptance" test has been the dominant standard for determining the admissibility of novel scientific evidence at trial (Green et al., 1983). In *Frye,* the Court of Appeals for the District of Columbia decided that the admissibility of evidence derived from a systolic blood pressure deception test, a precursor to the polygraph machine, was found inadmissible by the lower court as it had not gained a general acceptance among its peers to justify using expert testimony regarding it (*Frye v US,* 1923).

In 1922, a jury convicted James Alphonso Frye of second degree murder (*Frye v U.S., 1923*). His counsel argued on appeal that the trial court erred by refusing to allow Frye's expert witness to testify on the results of a systolic blood pressure deception test taken by Frye. In the underlying action, Frye recanted his confession to murder after he took and passed a deception test, then considered a new scientific test. Frye's counsel offered an expert witness to testify as to the validity of the deception test results, however the trial court did not allow the expert witness to testify without a general acceptance of the test in the scientific community.

After appellate consideration, the original conviction was left standing, as the court held that expert testimony regarding the deception test was properly excluded at trial because the deception test had not gained the required standing and scientific recognition from the scientific authorities on the subject (*Frye v. US*, 1923). Scientists had not yet proven this technique's accuracy or reliability, and there were no direct cases as precedence to help decide such an issue. The deception test works through a combination of simple medical tests. The examiner who administers the test to an individual monitors a person's heart rate, blood pressure, respiratory rate, and perspiration for sudden changes in response to a question posed to him. "The theory seems to be that truth is spontaneous, and comes without conscious effort, while the utterance of a falsehood requires a conscious effort" [which can be detected physiologically] (*Frye v US, 1923*). When a person is telling the truth, it is easy and their body is unchanged, but when telling a lie their body will show a change in at least one of those fields. In a now famous saying, the court held:

> "Somewhere in this twilight zone the evidential force of the principal must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently establiched to have gained general acceptance in the particular field in which it belongs." *(Frye v US, 1923*)

The testimony was not admissible as the evidence was not a generally accepted method. This case set a standard for what was considered to be acceptable scientific evidence in the eyes of the court. The so-called *Frye Standard* was used for many subsequent arguments in other court rulings. *Frye v US* also set a standard for allowing or disallowing expert testimony pertaining to complicated technical subjects.

U.S. v Downing (1985)

U.S. v Downing, much like the *Frye* case, elaborated on the admissibility of scientific evidence into trial. The two differ, as the Downing case dealt with the use of eyewitness testimony in trial, and whether it would be helpful in a particular case. The US District Court of Appeals found that testimony of this nature properly satisfies the 'helpfulness rule' or 'Rule 702'. This case also established the idea of a pre-trial hearing focusing on the admissibility of scientific evidence into trial.

John W. Downing was tried and convicted of mail fraud, wire fraud, and interstate transportation of stolen property in the United States District Court for the Eastern District of Pennsylvania (*U.S. v Downing, 1985*). Downing was accused of giving false information, such as name and records, to establish a business trust with different vendors. Downing took their goods to sell and never paid them back. The prosecution used the vendors as eyewitnesses to identify Downing (who also used other aliases), but the defense made an attempt to use expert testimony as to the unreliability of eyewitnesses. The District Court denied the defense's request, letting the eyewitness testimony stand, and Downing was declared guilty. The defense appealed the ruling to the Third Circuit Court of Appeals, and the appeal was successful as that court found the earlier District Court at fault for denying the expert testimony. The appellate court found flaws within the two main arguments the District Court made in their guilty verdict: 1) the first argument was "there was additional evidence such as fingerprints and handwriting"

(*U.S. v Downing, 1985*) (which was false as there was no additional evidence of this nature); and 2) "the witness would 'usurp' the function of the jury" (*U.S. v Downing, 1985*) (which was also proven invalid, other previous cases had also disallowed eyewitness testimonies). The Appeals Court used an Arizona case, *Chapple v. State*, as an example in which a new trial was granted to the defendant, allowing the testimony of the expert witness. The understanding behind these rulings is that without the testimony of the eyewitness, the jury by themselves can successfully make the correct decision based on "a proper cross examination" (*U.S. v Downing, 1985*). They also stated that testimonies of this nature fit the standards of the 'helpfulness rule', also known as *Rule 702*. This means that expert testimony would *help* the jury make a proper decision, especially in cases when the evidence the expert is testifying to is not common knowledge for the average juror.

The importance of the Downing case is seen daily, as it requires a 'pre-trial hearing' in which evidence for the case is presented and the judge rules as to whether or not it will be allowed in that trial, before the jury sees it. This Downing trial also reinforced the use of the 1975 Federal Rules of Evidence, also known as Rule 702, which was an easier standard to attain in real cases, than the difficult Frye standard of general acceptance, because it focused more on *reliability* and *helpfulness* of the technique than its general acceptance. In the pre-trial hearing, the judge will use Rule 702 to scrutinize the evidence for its:

> "(1) the soundness and *reliability* of the process or technique used in generating the evidence, (2) the possibility that admitting the evidence would *overwhelm*, confuse, or mislead the jury, and (3) the proffered connection between the scientific research or test result to be presented, and particular disputed factual issues in the case" (*U.S. v Downing, 1985*).

These three standards help assure the validity of the evidence in question.

Andrews v. State of Florida (1988)

This case was the first case to admit DNA evidence in a U.S. court. In Andrews, the Court Of Appeals of Florida held that genetic fingerprint evidence, comprised of strands of DNA whose profiles were compared for the purpose of identifying the perpetrator of a crime, was admissible. The court reviewed the history of the admissibility of scientific evidence to determine which standard applied to admissibility of a new scientific technique, and determined that the relevancy/reliability approach of *Downing* and *Rule 702* was proper. The court found that DNA evidence was reliable and had been applied for over 10 years in non-judicial applications, did not lead to erroneous results, was based on several accepted scientific theories, and there was extensive scientific literature on the subject. The court found the DNA evidence was reliable and thus admissible evidence.

In 1988, a jury convicted Tommie Lee Andrews of aggravated battery, rape and armed burglary. The victim reported to the police how the attacker had threatened her with a razor blade, held her down, raped her, and fled the scene of the crime with her purse. The victim had numerous cuts on her face and body, and semen from the rape was found in her vagina. The semen found was determined to have been left by a "secretor" (one whose bodily fluids contain traces of their own blood type). The semen was found to be blood type O, and although the victim was also blood type O, she was not a secretor. So the suspect was thought to be blood type O. In addition, for the first time in a U.S. courtroom since its 1985 introduction in England, DNA fingerprint analysis was applied to the semen sample and to the suspect Andrews, and the profiles matched.

Since DNA fingerprint technology was new in the U.S., the judge used a pretrial hearing as mandated by *Downing* to determine whether to admit the test results. Since the new technique had not gained general acceptance in the scientific community, the evidence did not meet the Frye Standard. So instead, the judge used the *reliability* standard of Rule 702, and the *relevancy* standard of Downing, to deem the evidence admissible, and the DNA evidence was used to convict Andrews despite its unproven *general* acceptance. Using the relevancy and reliability standards when analyzing an 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 have been applied" (*Andrews v. State, 1988*).

The judge allowed the testimony of an expert witness in the field of DNA to give his opinion of the evidence, Dr. David E. Housman, who explained the scientific facts behind DNA testing. Dr. Housman explained the method of 'restriction fragment length polymorphism' (RFLP, discussed in Chapter-1). The court was satisfied with how the test results were obtained, as many different control tests were performed to rule out significant errors.

This case was the first US case to accept DNA testing, and the technique would now be seen in the eyes of the public and the court as a reliable scientific source of information, for one year until the 1989 Castro case.

People v Castro (1989)

People v Castro led to the development of a 'Three Prong Test' to be used while obtaining acceptable DNA evidence. This test determined the admissibility of DNA evidence in trial, if these guidelines were not properly followed the evidence would not be allowed into trial. This set the standard for many cases to follow.

Joseph Castro was suspected of the murder of a seven-month pregnant woman, Vilma Ponce. Ponce had been stabbed to death also causing the death of her unborn child. While Castro was being questioned, blood believed to belong to Ponce was found on his watch. The watch was seized as evidence, and sent to a lab for DNA testing. The DNA tests proved that the blood on Castro's watch belonged to the victim. However, the defense argued that the DNA evidence obtained by Lifecodes Inc. should not be allowed in court, as the test was not properly controlled. Thus, DNA testing underwent the most rigorous analysis to date. The outcome was the enactment of a *three-prong* test to determine whether to accept DNA evidence:

> **Prong I**. Is there a theory, which is generally accepted in the scientific community, which supports the conclusion that DNA forensic testing can produce reliable results?
>
> **Prong II**. Are there techniques or experiments that currently exist that are capable of producing reliable results in DNA identification and which are generally accepted in the scientific community?
>
> **Prong III**. Did the testing laboratory perform the accepted scientific techniques in analyzing the forensic samples in this particular case?
>
> (*People v Castro, 1989*)

These tests ensure that DNA evidence obtained must go through three separate levels of approval before it is admissible in court. In addition to devising the three-prong test, a second major outcome of the Castro trial was the establishment of the "Technical Working Group for DNA Methodology (TWGDAM, 2008), whose task was to establish *standards* for performing DNA testing. In the Castro case, the DNA evidence was not allowed since Lifecodes had not performed proper controls, so prong-3 was not met. But the case never went to trial as Castro plead guilty.

Two Bulls v U.S. (1990)

Since 1989 the accepted method when obtaining evidence was the 'Three Prong Test' developed during *People v Castro*. *Two Bulls* elaborated on this test developing a new 'Five Prong Test', which resulted in a longer pre-trial hearing relying on the trial judge to properly weigh each argument then decide on admissibility.

Mathew Sylvester Two Bulls, Jr. was convicted of aggravated sexual abuse and sexual abuse of a minor by the United States District Court in South Dakota (*Two Bulls v US, 1990*). In the trial, DNA testing matched Two Bulls DNA profile with crime scene evidence, and the testing was allowed by the judge, and he was convicted. But the defense appealed the District court's ruling stating that the Castro Three Prong Test was not sufficiently met, especially the third prong. The appeal was successful as the District court's ruling was overturned by the Appellate court. The overturned ruling did not allow the DNA evidence into trial, so the prosecution argued two main points for allowing it: the first was that the Castro third prong for using *accepted* scientific techniques set too strict a standard in obtaining admissible DNA evidence, and the second was that *Rule 702* for *reliability* should be the more accepted standard as it is more flexible when pertaining to admissibility. Despite the prosecution's arguments, the appellate court stayed with their decision to not allow the DNA evidence into trial, and Two Bulls was acquitted of the charges. The appeals court stated that regardless of which standard is used, none will allow the DNA evidence to be used here as the method "fails normal foundational requirements necessary for the admissibility of scientific testimony or opinion" (*Two Bulls v. US, 1990*). The Two Bulls case led to an expansion of the Castro *Three Prong Test* into a new *Five Prong Test*:

Prong I. Whether DNA testing is generally accepted by the scientific community.

> **Prong II.** Whether the testing procedures used in this case are generally accepted as reliable if performed properly.
>
> **Prong III**. Whether the test was performed properly in this case.
>
> **Prong IV**. Whether the evidence is more prejudicial than probative in this case.
>
> **Prong V.** 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*)

This new *five-prong* standard resulted in a longer pre-trial hearing, as not only must the judge determine whether the test was properly controlled in each case, the judge must also determine whether the evidence is prejudicial in this instance, and whether the statistics are prejudicial.

People v. Miles (1991)

People v Miles furthered the prior precedences for the use of expert testimony in trial. Prior cases concerning similar situations were too vague as this case provided a more solid foundation regarding expert testimony. In this case the Appellate Court of Illinois, Fourth District, found that the DNA evidence used in the trial was admissible in court. Expert testimony would now be allowed when expert's field is seen as too complicated for the average juror to comprehend, thus the expert testimony would aid the jury in making their decision.

Reggie E. Miles was convicted in 1991 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 Vermilion County Illinois. During the trial, DNA evidence gathered from the various crime scenes was used against Miles. But the defense appealed the ruling to the Fourth

District Appellate Court of Illinois, arguing that the method used to gather this DNA evidence surpassed the understanding of average jurors. The court of appeals denied the appeal, and allowed the DNA evidence to be presented in trial, stating that "expert testimony is admissible when the expert has knowledge or experience not common to a layman" (*People v. Miles, 1991*). Thus Miles' earlier District Court conviction was upheld.

The Miles case further supported the use of expert testimony for explaining complex technology, and helped clarify the guidelines needed for using expert testimony in court. Following the harsh *Castro* and *Two Bulls* cases where DNA evidence was disallowed, the *Miles* case helped turn the tide back in favor of accepting DNA evidence in US courts.

Chapter-3 Bibliography

Andrews v. State of Florida (1988) District Court of Appeal of Florida, Fifth District, 533, Southern Series, 2d, pp. 841.

Federal Rules of Evidence (1975) Cornell University.
http://www.law.cornell.edu/rules/fre/rules.htm#Rule701

Frye v. United States (1923) Supreme Court of Appeals of District of Columbia, 293 F. 1013; 1923 U.S. App. LEXIS 1712; 54 App. D.C. 46; 34. A.L.R. 145, December 3, 1923, Decided.
http://www.patrickcrusade.com/FRYE_V_US.html
http://www.law.harvard.edu/publications/evidenceiii/cases/frye.htm

Green ED, Nesson CR, and Murray PL (1983) Problems, Cases, and Materials on Evidence. 3rd Edition. Aspen Publishers.

People v. Castro (1989) Supreme Court, Bronx County, New York, Criminal Term, Part 28, 545 New York State Series, 2d, pp 985.

People v. Miles (1991) Appellate Court of Illinois, Fourth District, Vol. 577 Northeastern Series, 2d ed., pp. 477.

TWGDAM (2008) "The TWGDAM Guidelines for a Quality Assurance Program for DNA Analysis, Section 4: Validation." Crime Laboratory Digest 181991 44-75. 29 July 2008 http://www.cstl.nist.gov/biotech/strbase/twgdam1.htm

Two Bulls v. United States (1990) United States Court of Appeals, 8th Circuit, Vol. 918 Federal Series, 2d ed., pp. 56.

United States v. John W. Downing. 753 F.2d 1224 (3rd Cir. 1985). http://www.altlaw.org/v1/cases/542949

Chapter-4: Sensational DNA Cases

Adam Walsh

The previous chapter discussed several landmark DNA courtcases that helped set legal precedence for accepting technical evidence in US courts, but most people are not familiar with those important cases. The two cases discussed in this chapter are likely quite familiar to the reader, and the purpose of this chapter is to review the cases pointing out the role that DNA evidence played, sometimes even decades after the crime was committed, as an indicator of the power of DNA technology.

The Boston Strangler

Thirteen Boston women were strangled in the early 1960's that sent a wave of fear to all residents of the area. While the police did not believe that these crimes were committed by one person, the public thought differently. The 13 murders seemed to by tied together, with similarities from case to case. All of the crimes were committed in the residence of the victim with no sign of forced entry. The victims were all strangled with some article of their own clothing, mostly their nylon stockings. They were also all sexually molested. The man the police were looking for came to be known as the Boston Strangler.

The Boston Strangler's first victim was a 55 year old woman named Anna Slesers who was found murdered on the evening of June 14th, 1962. When her son, Juris, came to pick her up for church that night, he received no answers to his knocking. Annoyed with the unanswered knocks, he forced his way into the apartment to find his mother murdered on the bathroom floor with the cord from her robe around her neck. The apartment was turned upside down but nothing was taken. Slesers was also found to be sexually assaulted. The police just believed that it was a burglary gone wrong. (Bardsley & Bell, 2003)

About three weeks later, on June 30th, two more women became the victims of the Boston Strangler. Sixty-eight year old Nina Nichols was found murdered with two of her nylon stockings tied in bows around her neck. There were signs of sexual assault. Like the case before, her apartment was ransacked and nothing was taken. Only fifteen miles from this crime scene in Lynn, Helen Blake was found with one of her nylons tied around her neck on the same day. Her apartment was rummaged through, but this time the killer took off with two diamond rings that Blake wore.

After a couple of weeks went by, the Boston Strangler struck again with his fourth and fifth acts. On August 19, Ida Irga, seventy-five years old, was found choked, sexually abused in her Grove Ave. apartment in the West End. Within twenty-four hours, across town, in Dorchester, Jane Sullivan, sixty-eight, was found dead in her bathtub, strangled by her nylons. She was not found for 10 days. No sign of forced entry were found in either case, but unlike the others, these apartments were not torn apart. (Bardsley & Bell, 2003)

Three months went by before the Strangler took his next victim. On December 5, a twenty-one year old girl was killed in her Huntington Avenue apartment. Sophie Clark was found strangled with her own nylons in her living room. There were signs of sexual assault and semen was also found on the rug. (Bardsley & Bell, 2003)

Three weeks later Patricia Bissette, a secretary for an engineering firm, was found with her nylons and blouse tied securely around her neck. A few more months went by and then in early March, Mary Brown, a sixty-eight year old from Lawrence, was found strangled and raped in her apartment. Shortly after that, a twenty-three year old graduate student became the next victim. Beverly Samans was found with her hands tied behind her back with one of her scarves, nylons tied around her neck. Unlike the other, the nylons were not the cause of death in this incident. Samans was stabbed twenty-two times, four fatal stab wounds in her neck, the other eighteen in her chest. Samans was not sexually assaulted. (Bardsley & Bell, 2003)

With the police getting nowhere in the case, they decided to seek help from a man who had ESP qualities named Paul Gordon. After speaking with police, Gordon surprisingly revealed details of the cases (that the police had not told him), and indicated that Arnold Wallace was the Boston Strangler. The police began to investigate Arnold, and found that he had been placed into a mental hospital, but had escaped from the hospital on the same days as the murders. But with more investigation, the police started to believe it was a hoax as they discovered that Paul Gordon, the psychic, had been to the hospital before he talked to the police, meaning he could have just searched for a patient whose release hours matched those of the killings, whether or not he committed them. Arnold was sent back to the hospital and was given a lie detector test, but the results were inconclusive. (Bardsley & Bell, 2003)

All was quiet during the summer of 1963, until September when a fifty-eight year old woman, Evelyn Corbin of Salem, was found murdered with two of her nylons tied around her neck. A tray of jewelry was found on the floor and her purse was ruffled through on the sofa, however, nothing was stolen. A fresh doughnut was also found outside her window, on the fire escape. Then on November 25, Joann Graff became another one of the strangler's victim. Graff, just like the other murders, was found with her nylons tied fastened around her neck and she was sexually assaulted. Teeth marks were found on her breast. This case was a little different than the other cases in that the killer may have been seen. At 3:25 am, a male student that lived upstairs from Graff heard footsteps in the hall, when he heard a man knocking at the apartment across from his he opened his door to speak with the gentleman. A young man of about twenty seven years old asked him, “Does Joan Graff live here?” Although the man mispronounced her name, at the time the student did not find it suspicious. Moments later, he heard someone enter the apartment of Joann Graff. (Bardsley & Bell, 2003)

The last of the Boston Strangler’s victim occurred on January 4th 1964. A nineteen year old woman, Mary Sullivan, was found strangled by her nylons. She was presented in a grotesque and shocking way, where a pink scarf was tied around her neck in a bow with another pink and white flowered scarf. She was in a sitting position with her back against the headboard of her bed. There were signs of sexual abuse present. The worst part was the killer left behind a “Happy New Years” card leaning against Mary’s foot. (Bardsley & Bell, 2003)

The public blamed the Boston police for not catching the Boston Strangler, so the case was turned over to Massachusetts Attorney General Edward Brooke on January 17, 1964. Brook created a special task force called the Special Division of Crime Research and Detection (SDCRD). This case spanned over five jurisdictions and the task force coordinated the activities of the departments. Brooke assigned Assistant Attorney General John S. Bottomly to lead this task force. The SDCRD never made any arrests or uncovered any new leads in the Boston Strangler case. A Dutch psychic working for the group did suspect a shoe salesman as the Boston Strangler, however there was no evidence whatsoever to link this man to the crimes so it was never pursued. People thought the Boston Strangler would never be caught, until one man finally confessed to being the Boston Strangler. (Bardsley & Bell, 2003)

Years prior to the Boston Strangler murders, a series of sexual offenses began to happen in the Cambridge area. The man arrested for these crimes was Albert DeSalvo, a 29 year old who had a record of breaking and entering. DeSalvo lived with his German wife and their two kids in

Malden, Massachusetts. When DeSalvo was a boy, his father used to beat him regularly and Albert was a delinquent. Albert joined the army in 1948 and was stationed in Germany, where he met his wife, Irmgard Beck. Eight years later, Albert was demoted for failing to obey an order, and later received an honorable discharge. In 1955 he was arrested for fondling a young girl, that same year his wife had their first child, Judy, who was born with a physical handicap. After the birth of their child, Irmgard was afraid to have another child and refused to have sex with Albert. This had a huge impact on Albert's life, who had a very strong sexual appetite. (Bardsley & Bell, 2003)

On October 27, 1964, a woman awoke to find a strange man in her apartment. She was alone in the apartment, the man started to kiss the woman and fondle her. The man then apologized, told her to be quiet and left. The woman went to the authorities, and because she got a very good look at the man a police sketch was made. The man was known as the Green Man because of his green work pants. From the woman's description, the police recognized the man as Albert DeSalvo and brought him to the police station so the woman could identify him. DeSalvo confessed to breaking into over 400 apartments, 300 assaults in 4 states, and several rapes. Since DeSalvo had the tendency to over exaggerate, many of these incidents went unreported. DeSalvo was then sent to Bridgewater State Hospital. (Bardsley & Bell, 2003)

While in Bridgewater, DeSalvo became good friends with an inmate, George Nassar. Nassar was a very dangerous man whose IQ reached a genius level and was capable to manipulate people. Nassar was sent to Bridgewater for an execution style murder on a gas station attendant. It was believed that while in prison together, the two devised a plan where DeSalvo would admit to being the Boston Strangler, and then the two would split the reward money.

DeSalvo already believed that he would be behind bars the rest of his life, so in doing this he could help take care of his family. (Bardsley & Bell, 2003)

On March 6, 1965, DeSalvo confessed to being the Boston Strangler. George Nassar's lawyer, F. Lee Bailey was the one who taped the confession from DeSalvo. Bailey convinced DeSalvo to take a lie detector test and to submit to questioning about the murders. In the recordings, DeSalvo gave detailed accounts about the murders and knew details only the person who committed the crimes could know. In September 1965, 50 hours of taped conversations and 2,000 pages of transcript were produced; the police and the SDCRD believed that Albert DeSalvo was indeed the Boston Strangler. (Bardsley & Bell, 2003)

Not everyone, however, believed that DeSalvo was the Boston Strangler. Those who were close to DeSalvo, his family, his former co-workers, and even some police who became familiar with him did not believe he was the strangler. Everyone knew him as a gentle and kind man, a man who could never commit these gruesome murders. Susan Kelly, author of *The Boston Stranglers: The Public Conviction of Albert DeSalvo and the True Story of Eleven Shocking Murders*, lays out many reasons why she believes he is innocent. One of the main reasons she points out is that there was no physical evidence linking DeSalvo to any of the murders. Second of all, none of the eye witnesses identified DeSalvo to be the stranger they saw on the night of the murders. Kenneth Rowe, the neighbor of Joann Graff who saw the stranger, was shown a picture of DeSalvo and could not positively identify him as the man he saw that night. Eileen O'Neil, who saw a man in Mary Sullivan's bathroom, also couldn't identify DeSalvo as the man she saw. The third reason she points out is an ashtray found in Mary Sullivan's bedroom had three fresh Salem cigarettes in it, neither Mary nor her roommates smoked that brand. The same brand of cigarette was found in the toilet of Sophie Clark, DeSalvo did not smoke cigarettes. Two additional witnesses were brought in to identify DeSalvo. One witness, Marcella Lulka, who lived in the same apartment building as Sophie Clark encountered a man who introduced himself as Mr. Thompson and stated that he was there to paint. The other witness was Gertrude Gruen, a woman who survived a strangulation attack. As DeSalvo entered the room, both witnesses excluded DeSalvo as the man they encountered, but when Nassar entered the room, Gruen became uneasy and thought something was oddly familiar about him. Later on, Gruen told the police that Nassar reminded her of the man who attacked her that night. (Bardsley & Bell, 2003)

Dr. Robey, the psychiatrist at the hospital, testified that DeSalvo had an extraordinary memory, "absolute, complete, one hundred per percent total photographic recall." Since the newspaper gave great detail about the cases, it was possible that DeSalvo just read about the murders, and re-stated the details to police in his “confession”. There were leaks in the agencies and unauthorized press conferences that distributed information on autopsies. Also it is believed that DeSalvo broke into the apartments of the victims after the murders happened, so he could get a good visual of the layouts. The rest of the details could have been attained from his stay in Bridgewater with George Nassar. The final argument DeSalvo is not the Boston Strangler is that the modi operandi were not identical in each case, so the crimes may have been committed by more than one person. There were specific differences in each case that provided evidence it was not one serial killer. (Bardsley & Bell, 2003)

DeSalvo was found competent to stand trial, and on January 10, 1967, he was tried on the Green Man charges. DeSalvo was found guilty and was sentenced to life in prison. But DeSalvo was never tried in the Boston Strangler cases. In November of 1973, DeSalvo phoned Dr. Ames Robey to meet with him and reveal the true story of the Boston Strangler. However, DeSalvo was involved with a prison drug operation that led to his fatal stabbing the night after he phoned Dr. Robey.

In 2001, DNA forensics was applied to the Boston Strangler case to see if DeSalvo was indeed guilty. The tests were led by a George Washington University professor, James E. Stars. They acquired DNA samples from the most recent victim, Mary Sullivan, and exhumed DeSalvo's body for autopsy. The DNA taken off of Mary Sullivan did not match the DNA of DeSalvo, proving that he was not the person who raped her. So the Boston Strangler case remains unsolved to this day. Perhaps DNA profiles can eventually be obtained from other victims of the strangler, and they can help determine whether there was one rapist or several, and maybe even allow an identification to be made to a database entry. (BBC News, 2001; Lavoie, 2001)

Orenthal "OJ" Simpson

In the early hours of June 13, 1994, a neighbor of Nicole Brown, Simpson's ex-wife, was awakened by a howling dog. When she went to investigate the noise, she found that the dog was covered in blood. There she found the bodies of Nicole Brown and Ronald Goldman, an acquaintance of Nicole Brown. The police responded, and this became the start of the longest jury trial in Californian history.

The double murder took place sometime around ten o'clock PM on June 12, 1994. Ronald Goldman was returning Brown's sunglasses which she left at a restaurant earlier that night when a man came in the back door of her home. The man brutally slashed Nicole Brown and stabbed Goldman 30 times.

The police soon suspected OJ on the basis of earlier problems with domestic violence. On the night of the murders, Simpson boarded a plane at 11:45 to Chicago. He received a ride from Allan Park, an employee of Town and Country Limousine Company at 11:00 PM. Park would later testify that he arrived at Simpson's home earlier at 10:25 PM, but there was no answer, so he came back at 11:00. Simpson checked into the O'Hare Plaza Hotel, where he was scheduled to attend a Hertz car convention. The police contacted Simpson Monday morning to inform him his wife had been murdered. When informed, Simpson asked no questions, and was on the next flight back to LA. (Linder, 2000)

The police investigated him for about a half an hour. They questioned the cut on his right hand, and he claimed that he did not remember how it happened. He later recalled that he cut it when he reached into his bronco on the night of the murders and then re-injured it on a broken glass. The interview was not helpful and it was discarded in the case. (Linder, 2000)

Several pieces of evidence at the crime scene pointed to OJ. Several blood samples were found whose DNA matched Simpson, including blood drops found on the ground near a shoe print, and in Simpsons white bronco. Shoe prints at the scene matched Simpsons. A now famous piece of evidence, an extra large pair of Aris Light gloves was also found, the left glove at the crime scene, and the right glove in Simpson's home, with blood on it. The shoe print was found to match shoes worn by Simpson. The gloves were found to be the same type as ones bought by Nicole in 1990 for Simpson. The police indicated Simpson for the murders of Nicole Brown and Ronald Goldman. (Linder, 2000)

Simpson's lawyer, Robert Shapiro, made an agreement with police that Simpson would turn himself in by 10:00 AM on June 17, 1994. When ten o'clock came and Simpson did not turn himself in, the police went to Simpson's house where they found an apparent suicide note, but there was no sign of Simpson anywhere. Around 6:20 PM a motorist called police that he saw Simpson driving a white bronco. The police pursued the bronco, and Simpson started a famous slow-motion chase that finally ended in Simpson's driveway. In the bronco the police found $8,750, a fake beard and mustache, a loaded gun, and a passport. Simpson was arraigned on July 22, 1994 where he plead, "Absolutely one hundred percent not guilty, Your Honor." (Linder, 2000)

The trial of OJ Simpson began on January 24th, 1995. The prosecution's opening statement, led by Christopher Darden and Marcia Clark, said they would show OJ to be an abusive and jealous lover of Brown. They argued "If he couldn't have her, he didn't want anybody else to have her." They summarized their evidence facts that they said proved Simpson killed Nicole Brown and Ronald Goldman. The next day, the defense made their opening statements. Johnnie Cochran, Simpson's lawyer, presented a timeline of events that was very confusing and argued that his arthritis made it impossible to commit a double murder. He was going to prove that the evidence the prosecution gathered was "contaminated, compromised, and ultimately corrupted." (Linder, 2000)

For the next 99 days, the prosecution brought forward 72 witnesses to try to prove Simpson guilty. The first set of witnesses addressed Simpson's abusive behavior. Denise Brown, Nicole's sister, testified that she witnessed many instances where Simpson showed abusive behavior towards Nicole. She said that she saw Simpson on the day of the murder and claimed that he looked like a "madman." A friend of OJ, Ron Shipp, testified OJ told him that he had dreams of killing Nicole. The next witness was a 9-1-1 dispatcher, who played a recording of a call where Brown reported spousal abuse. (Linder, 2000)

The next set of witnesses was used to elaborate on the timeline. The first witnessed called was Allan Park, the limousine driver, who testified that he arrived at the Simpson residence at 10:25 PM but received no answers to his knocks. At about 11:00 PM he noticed a shadowy figure, resembling OJ, walk up and enter the house. Moments later, Simpson came out of the house and explained that he overslept. Simpson was carrying a small black bag that he refused to let Park touch. The next witness was Kato Kaelin, who was the house guest of Simpson on the night of the murder. Kaelin testified that he and Simpson went to McDonalds and returned to the house at 9:36 PM. Charles Cale, Simpson's neighbor, testified that between 9:30 and 9:45, he was walking his dog and did not see Simpson's bronco in the driveway. (Linder, 2000)

The final set of witnesses testified to the physical evidence arguing that Simpson was present at the crime scene. The technical and circumstantial evidence consisted of blood, hair, fiber, and a footprint found at the crime scene. The blood was subjected to an RFLP type DNA test (discussed in Chapter-1 of this IQP). These tests showed that the blood found at the crime was indeed Simpsons, and only 1 out of 170 million could produce that blood. The blood from the black socks in OJ's room showed that only 1 out of 6.8 billion could produce that same blood, and that person is Nicole Brown. The defense tried to convince the jury that either the evidence was contaminated or it was planted by corrupt police. The defense argued that Mark Fuhrman, the police officer that found the evidence, was a racist; the defense asked him if he had ever used the n-word. Fuhrman lied and said no. This later back fired when the defense presented a witness who had previously interviewed Fuhrman where he used the n-word, so this was used against Fuhrman to prove that he could be a racist and could have planted evidence. The next set of evidence was the set of bloody gloves, one found at the crime scene and one at Simpson's house. In a famous scene, the prosecution presented Simpson with one of the gloves and asked him to put it on. When Simpson attempted to put it on, the glove did not fit. Whether the glove shrank from being wet or from the blood the jury saw that the glove did not fit. (Linder, 2000)

The defense called their own witnesses to disprove the evidence brought on by the prosecution. They wanted to show Simpson was physically incapable of committing this crime, to point out flaws in the timeline presented by the prosecution, and to show the technical evidence was contaminated, planted, or both. The first witnesses were Simpson's daughter, sister, and his mother which were all used to try to gain empathy from the jury. Simpson's doctor testified that Simpson was not in good health and unable to commit these murders. The prosecution came back with a video of Simpson engaging in physical exercise. There were two key witnesses that helped make the defense's case. The first one was a screenwriter named Laura Hart McKinney, who testified that in interviews with Fuhrman, he used racial slurs and admitted to planting evidence in other crimes to secure convictions. The second witness was Henry Lee, a forensics expert with excellent credentials. Lee testified that the shoe print evidence suggested that there may have been more than one person at the crime scene, and believed that there was "something wrong" with the conclusions of the DNA tests. He argued that the blood was packaged wrong which could have contaminated the evidence. There was also a deliberation on how the blood was stored, the defense argued that since the samples were kept in a lab truck the blood would be partially degraded, and since it was not it must have been switched. (Linder, 2000)

In the closing statements, Marcia Clark tried to do damage control on the issue of Fuhrman being a racist. She agreed with the defense and called him a racist, the "worst type" of cop, but she told the jury that does not mean he planted to the evidence in this case. Darden followed up by saying Simpson "could be a great football player and a murderer as well." But the defense had planted just enough doubt to allow the jury to acquit Simpson in the criminal case. The jury only spent three hours deliberating and they concluded that Orenthal James Simpson did not kill Nicole Brown and Ronald Goldman. (Linder, 2000).

In a subsequent *civil* case, where the jury makes their decisions based on the *preponderance* of evidence instead of the "beyond all doubt" standard of a criminal trial, Simpson was found guilty and held liable for both murders. Following the OJ case, the training of law enforcement officers tightened the protocols for collecting and storing DNA evidence, and the chain of custody documentation to prevent potential tampering (discussed in Chapter-2).

Chapter-2 Bibliography

Bardsley, Marilyn and Rachel Bell (2003) The Boston Strangler. Court TV's Crime Library. http://www.trutv.com/library/crime/serial_killers/notorious/boston/index_1.html

BBC News (2001) DNA Doubts Over Boston Strangler. http://news.bbc.co.uk/1/hi/world/americas/1696552.stm

Kelly, Susan (1995) Boston Stranglers: The Wrongful Conviction of Albert DeSalvo and the True Story of eleven Shocking Murders. Carol Publishing Group.

Lavoie, Denise (2001) DNA Evidence Stirs Doubt in Boston Strangler Case. Los Angeles Times, Dec 7, 2001. http://www.latimes.com/news/nationworld/wire/sns-bostonstrangler.story

Linder, Douglas (2003) Famous American Trials: The O.J. Simpson Trial. http://www.law.umkc.edu/faculty/projects/ftrials/Simpson/simpson.htm

Chapter-5: DNA Databases

Sean Donnelly

Introduction

There was a time in this country when one would a commit a crime and could be punished for that crime only if: 1) someone had witnessed it, or 2) their fingerprints or other personal items were left behind. However, due to a rise in DNA technology in the past twenty or so years, and advancements in forensic science (discussed in previous chapters), DNA can now be used to directly place a criminal at a crime scene. With a strand of hair or a droplet of body fluid, scientists can match a suspect's DNA to that of the DNA from the crime scene. Forensic scientists from the FBI or local government agencies submit DNA profiles and criminal records into the FBI's Combined DNA Index System (CODIS) database to help identify criminals, or to determine that individual crimes are actually related. From a purely crime solving perspective, DNA fingerprinting has been termed the greatest tool in the history of forensic science, but while some think these databases are a great resource, others believe it is unethical to place an individual's private DNA or criminal information into a database (IAFIS, 2008"). The information can be flawed, and some believe that an individual's privacy rights are violated if the information contains medical predisposition information. Thus, DNA databases can have both a positive and a negative impact on society. The purpose of this chapter is to investigate the ethical considerations of DNA databases.

DNA Databases and Criminal Justice

The advancements in DNA forensics have made the jobs of detectives, crime scene investigators, and forensic scientists much easier than in the past. Instead of needing a witness or a traditional fingerprint, scientists and detectives can place a criminal at the scene of a crime with just a strand of their hair or a drop of their saliva, by matching the sample's DNA profile to a suspect or to a profile in a database (representing previously convicted felons or other crime scene profiles). However, if a person has no previous criminal history, their DNA profile will not be found in the database. So if no match occurs to previous felons, detectives must have enough evidence to get a warrant for a suspect's DNA to place them at the crime scene.

This new technology can be used to put criminals behind bars and off our streets with just a click on a computer. For twenty years now, once a suspect has been placed at a crime scene, law enforcement agencies have been able to convict individuals of crimes they committed without a witness, or without a complete picture of the act itself. As we discussed in Chapter-4, even 50 year old crimes in cold cases can be solved as new technology is applied to the case.

Freeing the Falsely Accused

DNA databases can be used more than just to convict the guilty, they can also be used to free the innocent. Due to the power of DNA testing to solve old crimes, new funded programs have been put in place to re-test imprisoned individuals to see whether their DNA profile matches crime scene DNA evidence. The Innocence Project is a non-profit organization dedicated to exonerating wrongfully convicted people through DNA testing. The organization also works to reform the criminal justice system to prevent future injustices (InnocenceProject.org, 2009).

In one case, the Innocence Project worked on the case of Ralph Armstrong, and eventually got his rape and murder charges dismissed after 29 years in prison. In 1980, Armstrong had been arrested and convicted for murder in Wisconsin, and served 29 years. But he was subsequently proven innocent by DNA testing, and released this year on August 19, 2009 (Ferrero, 2009). In another case, Kenneth Ireland from New Haven, CT, had been arrested and convicted of murder and rape, and sentenced to 50 years, for a crime he never committed. On August 19, 2009, Ireland was released and returned back to New Haven. "I feel amazing, it feels amazing. It's been a long time coming and I've just got to breathe now," Ireland said as he walked out of the courthouse. He always claimed he was innocent and the Connecticut Innocence Project decided to pick up his case. After testing Ireland's DNA profile and comparing it to that from crime scene evidence, they determined there was no way Ireland could have been the killer (Pierce, 2009). Many people have been set free and given back the freedoms that were taken from them for so many years due to the use of DNA profile testing and DNA databases. It is with the use of this technology that scientists, law officials, and organizations such as the Innocence Project can correct the injustices of the past.

Scientific Uses of DNA Databases

DNA databases do not just have forensic applications, they can also be used to find new scientific discoveries such as the cure for an inherited disease. By studying human DNA, scientists have found, for example, that some diseases such as the early onset type of Alzheimer's disease are passed on through genetics. Several genes have been linked to Alzheimer's: APP, Apo-E4, Presenilin-1 (PS1), and Presenilin-2 (PS2). Through studying these genes, scientists can predict the possibility of Alzheimer's in a person and how early the effects will set in. By studying early onset genetic cases of Alzheimer's disease, and the mechanisms of cell death in the brain, scientists can also gain insight into what causes the later versions of the disease. Without analyzing human DNA, scientists cannot learn how our DNA and its genes affect us making us susceptible to disease (Adams, 2000).

Database Ethics, Civil and Privacy Rights

From a crime solving perspective, some scientists believe that everyone's DNA should be entered into a database, say from a cheek swab taken at birth, to eventually make a "perfect" database to test crime scene samples against. Although this seems like a good idea for forensics as an individual would not have to commit a previous crime to be caught, it brings up a great ethical debate as to who should be required to enter their DNA profile into a database.

Who Should Provide DNA Samples?

Currently the strictest states have passed laws forcing those *arrested*, whether convicted or not, to submit a traditional fingerprint and DNA profile to a database. However, most states have taken a more modest approach. For example in Massachusetts, Chapter 107 of the Acts of 2003, Section 1, states, "Any person who is *convicted* of an offense that is punishable by imprisonment in the state prison, and any person adjudicated a youthful offender by reason of an offense that would be punishable by imprisonment in the state prison if committed by an adult shall, within one year of such conviction or adjudication, submit a DNA sample to the department, which shall be collected…" (Mass.gov, 2003). In other words, in Massachusetts if you commit a crime serious enough to be sent to jail you must submit your DNA to the agency that arrested you, and you will be entered in to the system so that if you commit another heinous crime, you are already in the system and easy to prosecute. Though some see this as an invasion of privacy and civil rights, others believe that once you commit a crime you have sacrificed your rights and should provide the DNA sample. Currently, if you commit no crimes (arrersted or convicted) you will not be subject to such laws.

Currently, most states vary as to who must contribute DNA samples. Most states want violent individuals' and repeat offenders' to contribute, while others want the DNA of as many people as possible input in to the databases. Those in favor of having as many individuals as possible in the system have the idea that if we enter more criminals into the system we are more likely to get a hit on cases that have DNA samples. States with this approach to DNA testing include Arkansas, Illinois, Florida, New Jersey. These states recommend that all individuals convicted of felonies, juvenile offenses, and even misdemeanors be included in the database (National Conference of State Legislatures…2005). These states also believe if you already have to enter your traditional fingerprint into a system when you are arrested, why not take the additional few seconds it takes to painlessly swab an individual's mouth to obtain cheek cells with DNA.

Other states view entering as many people as possible into the system as unethical and unnecessary, and require only criminals convicted of violent crimes to provide DNA. States with this approach include West Virginia, Oklahoma, Indiana and Connecticut. These states find it unethical and unnecessary to require all criminals to provide their DNA, and therefore tend to make only those convicted of violent crimes or felonies contribute their DNA (Conference of State Legislatures…2005).

In San Francisco, California affiliates of the American Civil Liberties Union filed a lawsuit against the state challenging Proposition 69, which requires DNA testing for individuals *arrested* but never convicted of the crime, including those who are acquitted, had charges dropped, or were later found innocent. Proposition 69 also requires those who were sentenced to a crime in the past and have already served their time and are under no legal supervision to submit a sample of their DNA, showing our lack of trust in the rehabilitation system.

This year the FBI came out with a new plan to vastly expand the DNA database system aiming to include millions of individuals who have been arrested or detained, but not yet convicted. They claim that moving in this direction will help solve more crimes in both the past and future. As of right now there are 6.7 million profiles in the CODIS database, and the FBI aims to add 80,000 a year to make 1.2 million profiles by 2012. 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).

False Imprisonment

In some cases, two individual's DNAs are similar enough to provide similar profiles that can result in false imprisonment (Brenner, 2004). If an individual's DNA happens to match a crime scene profile in a database, they could be arrested based solely on that evidence. Although in most cases, DNA evidence is backed up by other corrorborating evidence, such as motive, access to the crime scene, etc, in some cases individuals have been arrested solely on matches to a database (Brenner, 2004). This occurred more frequently in the early years of DNA testing, but as testing got more sophisticated, and more loci were included in the analysis, probabilities of such random matches has greatly decreased. For example, when a DNA analysis includes the current 13 core loci recommended for entering a sample into CODIS, the probablity of a random match to another individual is one in ten billion (Brenner, 2004).

Medical Predispositions and DNA Databases

As discussed above for Alzheimer's disease as an example, if DNA analysis can determine some medical predispositions, then can one determine medical predispositions from DNA databases? Privacy rights groups have been warning for years about "big brother" knowing everything about an individual from their DNA database profile (Bereano, 2000). So what would happen if someone hacked into the database to obtain the profiles and sold them to insurance companies. These companies could perhaps deny an individual medical insurance coverage if they believed they were predisposed to an expensive disease to treat (Bereano, 2000).

For example, many individuals view DNA testing as invasion of privacy as attorney Maya Harris, director of the ACLU of Northern California's Racial Justice Project stated, "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). People do not want their personal family issues being given out as public information just because they were accused of a crime they had not committed.

This debate focuses on the *type* of information entered into databases. Although as was pointed out earlier, scientists are beginning to identify versions of genes that predispose an individual to specific diseases, these genes do not always lead to the disease. Moreover, this information is <u>not</u> the type entered into CODIS. No medical predisposition data has ever been tied into any of the very carefully chosen 13 core loci, so by hacking into CODIS, no criminal could ever obtain more information than has been entered into it.

One valid point, however, is that the stored original DNA sample could be stolen and re-tested, not for the 13 core loci but other loci involved with medical predispositions. This is a valid concern, but the author of this chapter feels it is easily solved by passing laws demanding that the original DNA samples be destroyed once the 13 core loci information have been analyzed.

Other Ethical Concerns

Some individuals might perceive DNA databases as going against the idea of imprisonment being for the purpose of rehabilitation. If prison is supposed to rehabilitate a person, then once rehabilited, why would the government need to keep an individual's information in a database assuming they will commit another crime? While this country gives us several freedoms and rights, once we commit a crime they try to take some of those rights away.

Chapter-5 Conclusions

As is typical of all new technologies, they usually come with ethical debates on their uses. While DNA databases and DNA testing serve as a powerful means for putting criminals behind bars, and allow for new scientific discoveries, some state laws could subject innocent individuals to forced DNA testing, or expose their private genetic information. The author of this chapter believes that government officials should provide strong oversight of this new technology. It is a common misperception that hacking into the CODIS database could reveal an individual's medical predisposition, however no genetic predisposition data exists in the 13 core loci entered into CODIS. However legislation should be passed mandating destruction of the original DNA sample after the 13 core loci have been analyzed so additional testing can not be performed that *could* provide medial predisposition data.

With respect to *who* should provide DNA samples to databases, some will always want to enter as many criminals into the system as possible to help put criminals behind bars, while others will constantly find it unethical and against their civil liberties to be forced to submit a DNA sample. The author of this chapter believes that we as a society should step in a direction that will better us all, and if that means submitting more DNA samples, then we need government officials to pass legislations mandating that all individuals convicted of violent crimes, felonies, misdemeanors, and especially habitual offenders at any level of crime, submit a DNA profile into the database. With the use of this legislation law enforcement individuals can put more criminals behind bars and keep them off the streets. When it comes to the ethical debate of civil rights and privacy, the author of this chapter believes that once an individual commits a crime they made the choice themselves to give up their own rights by committing that act. Advancements in DNA forensics have brought more good than harm, and should continue to be used to convict criminals of their crimes, and to free the innocent.

Chapter-5 Bibliography

"ACLU Challenges California Law Permitting Government Seizure of DNA Samples" (2004) American Civil Liberties Union. 7 Dec. 2004. Accessed 28 July 2009. www.aclu.org/privacy/gen/15767prs20041207.html.

Adams, Amy (2000) "Genes Can Cause Alzheimer's Disease." Genetic Health, 5 Sept. 2000. Accessed 27 July 2009. www.genetichealth.com/ALZ_Genetics_of_Alzheimer'_Disease.html

Bereano, Phillip (2000) Does Genetic Research Threaten Our Civil Liberties? http://www.actionbioscience.org/

Brenner, Charles (2004) "Forensic mathematics of DNA matching." Accessed 5 Aug. 2009. www.dna-view.com/profile.html.

Ferrero, Eric (2009) Innocence Project Statement on Decision Dismissing Murder Charges Against Ralph Armstrong After 29 Years. Innocence Project. Accessed 20 Aug. http://www.innocenceproject.org/Content/2124.php.

IAFIS (2008) "Integrated Automatic Fingerprint Identification System of IAFIS". Federal Bureau of Investigation. Accessed 27 July 2009. www.fbi.gov/hq/cjisd/iafis.htm.

InnocenceProject.org (2009) "About the Innocence Project." Innocence Project. Accessed 19 Aug. http://www.innocenceproject.org/about/ .

Mass.gov (2003) "An Act Relative to the State DNA Database". Commonwealth of Massachusetts. Accessed 5 August 2009. www.mass.gov/legis/laws/seslaw03/s1030107. html.

Moore, Solomon (2009) "FBI and States Vastly Expand DNA Databases." *New York Times.* Accessed 20 Aug. http://www.nytimes.com/2009/04/19/us/19DNA.html?_r=1

National Conference of State Legislature (2005) State Laws on DNA Data Banks Qualifying Offenses, Others Who Must Provide Sample. http://www.ncsl.org/programs/cj/dnadatabanks.htm

Pierce, Kent (2009) "DNA Clears Man of Murder, Rape." Accessed 20 Aug. http://www.wtnh.com/dpp/news/crime/news_wtnh_new_haven_dna_clears_man_charges_to_be_dropped_200908190544 .

PROJECT CONCLUSIONS

Deoxyribonucleic acid (DNA) is the material in almost all organisms which contains the genetic instructions for biological development. The sequence of its main components specifies the information needed to make us all human. Although our DNAs are about 99.9% identical, distinguishing us from other species, forensic scientists are interested in that small portion that makes us unique. DNA fingerprinting technology allows the differences between individual DNAs to be determined, providing forensic scientists with an amazing tool for comparing crime scene DNA with suspects, allowing scientists to study human migrations and evolution, and allowing the military to identify unknown remains. The main ways of obtaining DNA fingerprints include VNTR analysis, STR analysis, RFLP analysis, and PCR.

DNA forensics is the most important tool law enforcement has at a crime scene. It is so important that an entire investigation can hinge on the first responders being able to properly secure the scene, identify evidence, and store the evidence correctly to prevent DNA contamination or degradation. DNA evidence can only be used in a court of law if the chain of custody is followed, and the DNA evidence is properly stored.

DNA fingerprinting technology has been heralded as the greatest tool in the history of forensic science. However, its acceptance as evidence in courts in the United States has not been simple. In fact, the acceptance of any new scientific technology, such as polygraphs, spectroscopy analysis of chemicals, DNA profiling, etc. as court evidence is not without obstacles because of the lack of legal precedence and a lack of technical understanding of a new concept. Since DNA's first use in U.S. courts in 1988, the guidelines for its use have been rewritten numerous times. Landmark court cases have paved the way for what is acceptable or admissible evidence in court.

The public is often unfamiliar with the landmark cases, but instead learn about DNA fingerprinting through sensational court cases. In the case of the Boston Strangler, DNA evidence was not used in the original case (since it was not yet invented), but instead it used decades years later to try and solve the case. DNA was taken from the latest victim and it was proven that the man who claimed to be the Boston Strangler, Albert DeSalvo, did not rape the victim. In the "trial of the century" much DNA evidence proved that OJ was at the crime scene. However, it was shown by the defense that the DNA was not stored properly, so therefore the evidence was potentially contaminated which shed some doubt on the case. He was eventually acquitted in the criminal case, but convicted in a subsequent civil trial. This case led to the tightening of training law enforcement officers on the protocols for collecting and storing DNA evidence, and on ensuring evidence chain of custody to prevent any potential tampering.

As is typical of all new technologies, DNA fingerprinting has its ethical debates. While DNA databases and DNA testing serve as a powerful means for putting criminals behind bars, and allow for new scientific discoveries, some state laws could subject innocent individuals to forced DNA testing, or expose their private genetic information. The authors of this IQP believe that government officials should provide strong oversight of this new technology. It is a common misperception that hacking into the CODIS database could reveal an individual's medical predisposition because no such genetic predisposition data exists in the 13 core loci. However, legislation should be passed mandating destruction of the original DNA sample after the 13 core loci have been analyzed, so additional testing can not be performed that could provide medial predisposition data.

With respect to who should provide DNA samples to databases, some will always want to enter as many criminals into the system as possible to help put criminals behind bars, while others will constantly find it unethical and against their civil liberties to be forced to submit a DNA sample. The authors of this report believe that we as a society should step in a direction that will better us all, and if that means submitting more DNA samples then we need government officials to pass legislations mandating that all individuals including those convicted of violent crimes, felonies, misdemeanors and especially habitual offenders submit a DNA profile into the database. With the use of this legislation law enforcement individuals can more easily put criminals behind bars and keep them off the streets. When it comes to the ethical debate of rights to privacy, once an individual commits a crime they made the choice themselves by committing that act to give up their own rights, so should be compelled to provide a DNA sample. Advancements in DNA forensics have brought more good than harm, and should continue to be used to convict criminals of their crimes, and to free the innocent.