CONTINUING LEGAL EDUCATION

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BASIC DNA AND CONTEXTUAL CONTAMINATION IN CASES

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Session 1 Outline: Basic DNA and Contextual Contamination in Cases

PowerPoint 1: 1 hour

1. Basic DNA facts and genetic inheritance
    a. Powerful forensic tool but must be correctly applied and interpreted
    b. Power of DNA comes from fact that generally, the DNA profile from forensic samples will be identical regardless of body fluid or tissue source
    c. A recent NY Times article discussed chimeras, however, in forensics, years of information have shown forensic samples do not suffer from this. Chimeric profiles originate from or typically form in internal tissues in early human development, and are observed in human organ transplants and full body blood transfusions (shootings/stabbings). Recovery of original DNA profile after blood transfusion is approximately 30 days.
    d. Nuclear DNA profiles come from 23 pairs of chromosomes (autosomes) found in a cell nucleus, 1 per cell.
    e. Cytoplasmic DNA profiles (mitochondrial) come from hundreds of circular chromosomes found in liquid portion of the cell, 100-1000's per cell.
    f. Nuclear DNA is unique to each individual IF it comes from a single source profile. In partial profiles or mixtures of individuals, the power of uniqueness diminishes and coincidental matches increase.
    g. Individuals who are related will share significantly more DNA than unrelated individuals when surveying known relatives and full DNA profiles. Siblings: 50% (identical twins 100%), and more distant genetic relatives can share on average 30% or less.
2. DNA extraction is the process of mechanical and chemical rupture of the cell and purification of all DNA by removal of lipids (fats), proteins and carbohydrates. During the extraction process, trace amounts of DNA can be lost and many forensic samples contain only a few usable cells for DNA profiling. For this reason, polymerase chain reaction (PCR) is performed to copy specific regions of DNA known to be variable in individuals. Approximately 99% of our human genome is similar; it is the 1% that is different that we use in DNA tests. There is no medical value to forensic DNA tests and use is restricted to identification purposes.
3. Why is DNA such a powerful forensic tool? Each target region is on separate chromosomes, so like a deck of cards, each target region is inherited randomly (shuffled) so that an incredible number of combination can be generated, and thus, we achieve DNA uniqueness.
4. Terms used in DNA reports: definitions for chromosome, locus, allele, coincidental matching, low copy number DNA and high sensitivity testing
5. How do we visualize a locus or allele? (graphic of 1 chromosome)
6. How do we visualize a mixture? Quantities of DNA expected from a single cell or from touch DNA(picograms) vs. target amount in standard DNA testing (1nanogram)-sensitivity of detection (picogram amounts but risk of data loss at low levels) and specificity as human DNA (from DNA primers in test). Risk of increased detection of contamination through inadvertent transfer; primary and secondary transfer.
7. What are some average estimates for forensic DNA samples? (graphic) – discussion on quantity versus quality and effect on ability to generate a DNA profile
8. Minimal contact time to observe any DNA on the surface of an item is 30 seconds. Increased handling time, genetics (shedder vs. nonshedder status), washing, lotions, perspiration, gloves etc. will all affect ability to detect DNA on an object.

9. Where does touch DNA come from? The cells that are sloughed off the surface of skin are called keratinocytes, approximately 40,000 per day. It would seem like we are leaving DNA everywhere (which we are) but many of those cells lack a defined nucleus, so the DNA detected may come from "free DNA or perspiration" rather than intact cells.
10. In shedder studies, from thumbprints and 30 seconds of pressure; there is a dominant genetic ratio that occurs on a consistent basis of 3:1 indicating DNA shedding at higher rates is a fairly dominant trait. This is a rough approximation but should reinforce that often it is a surprise to find no DNA at a scene. High sensitivity studies are designed to generate a DNA profile even from the "nonshedders" who might leave only 5 cells behind. However, that also means, better quality control and assessment of prospects of contamination or a reasonable reason for why DNA may be present need to be carefully considered.
11. Discussion and definitions on transfer of cells and mechanisms of contamination. Reference to aerosol and surface contamination studies in laboratories.
12. DNA technology has changed a lot over the past 15 years; from simple band patterns of restriction fragment length polymorphism (RFLP) tests to the standard 15 locus profile used in short tandem repeat (STR) technology. Recent forensic kit advancements have added loci so that soon you will see references to kits such as Globalfiler and PowerPlex Fusion which will each use 24 loci to profile individuals for standard DNA testing.
13. Steps in DNA Analysis: extraction, quantitation, amplification, detection and interpretation.
14. How is DNA detected in instrumentation? DNA is tagged with fluorescent dyes and after injection, excited by a laser as the dye migrates through a polymer matrix in a closed capillary tube. DNA fragments are recorded by collection software to define time and length and then analyzed by interpretative software to establish a DNA profile. In addition to the software analysis, interpretation by the analyst is required to rule out any instrumentation or method-based artifacts in testing as well as data in the baseline.
15. DNA quality and quantity plays a role in how well the interpretation software performs and this a large part of the backlog in analysis of DNA samples.
16. Analyst interpretation then is required to establish different report conclusions as shown here. These are usually listed on the back pages of any of the DNA reports provided to you. Discussion of the definitions and what they mean for DNA testing.
17. How often does an analyst or laboratory make an error in a DNA case? It is difficult o assess and measure but the average "guestimate" is 1 per 100 cases. Errors can fall into a wide variety of categories but should be fully disclosed when discovered to both sides in a case. These are recorded internally in laboratories by the quality manager in quality assurance records or documents that are discoverable. General categories of error occur due to contamination, reporting and interpretation of the data (more detail to be discussed in session 2: DNA mixtures and statistics).

PowerPoint 2: 1 hour

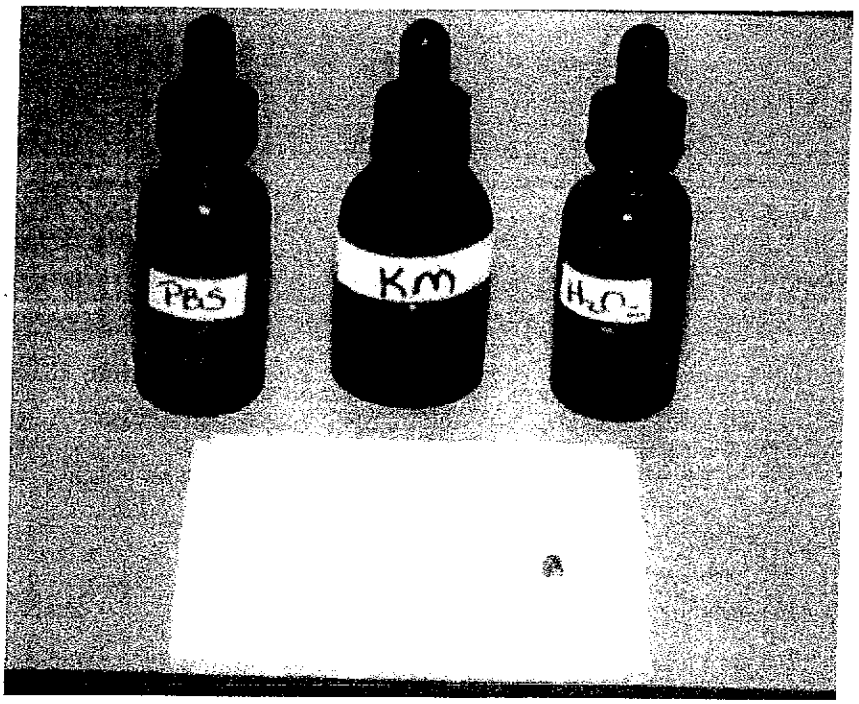
1. Contextual contamination – misapplication or misinterpretation of scientific information in forensic casework
2. Description of a North Carolina case (State of North Carolina v. George Goode Jr., 1993) where original blood evidence documentation was negative, DNA was used post-conviction to attempt to prove blood existed by the prosecution after comingling of clothes from defendants and victims. However, in course of examining this case and others for review, a significant number of blood identification errors were discovered.

3. Discussion of Swecker and Wolf Report-bigger picture-and forensic laboratory protocol and training problems those lead to more than 200 cases being reevaluated and several exonerations.
4. Description of North Carolina case (State of North Carolina v. Samuel McCullum, 2007) where interpretation of a variety of DNA evidence for probative value resulted in prosecution dropping the case.
5. Article: Collins, J. and J. Jarvis, 2009. Contextual Contamination of Forensic Evidence by Post-Conviction Litigators. Crime Lab Report. pp.1-20. –Arguments for positive and negative uses of forensic science test results, need for error rates and better quality assurance, and reasons behind exonerations or misinterpretation or misapplication of the evidence.
6. Scientific precision v. scientific accuracy discussion – qualitative v. quantitative results; positive, negative and inconclusive are all valid scientifically accurate results.

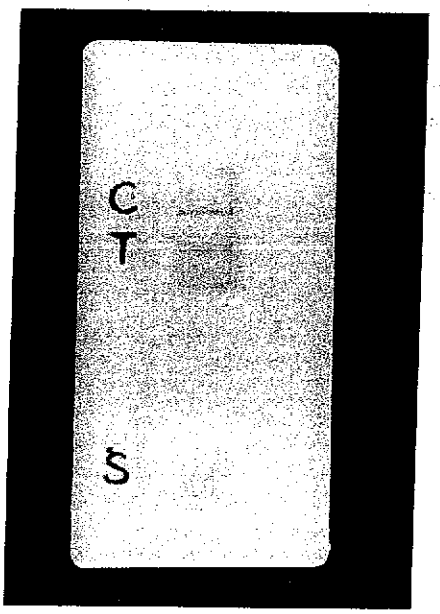
Presumptive and Confirmatory Blood Identification

The word presumptive means that a test result can be read as "could be blood." What is the purpose of performing a test that is not specific for human blood? In forensic science, hundreds of samples are collected in casework and a rapid, sensitive assay to allow for quick screening for possible blood at the crime scene or in the laboratory is critical for maintaining effective work flow. However, scientific accuracy is required for legal purposes so a second confirmatory test specific for human blood is performed that may be less sensitive that the first assay but is more specific to human blood. The two tests combined and when performed properly give highly sensitive and specific results for human blood identification. Forensic laboratory procedure needs to be tightly monitored and protocols need to be evaluated to insure that scientifically accurate results are being obtained. Although many blood identification tests exist, two commonly used tests are shown here:

Phenolphthalein – also known as Kastle-Meyer reagent, this test is a presumptive blood identification test for detection of "possible" blood, human or otherwise, so the test lacks human specificity. The basic test involves taking a trace amount of sample and hydrating with a drop (20ul) of sterile water or phosphate buffered saline for 10 seconds. A drop of Kastle-Meyer reagent (20ul), a pH indicator, is added to the hydrated sample. After 20 seconds, the sample is checked to insure that no color change has occurred as at this point, the sample should be colorless or the original color. With the addition of a third reagent, hydrogen peroxide (20ul), a rapid color change to pink should occur with 30 seconds. This indicates a "possible" presence of blood and confirmatory testing should be subsequently performed. Quality control for this test includes the following: (1) a known blood sample (positive control) and a negative substrate sample (negative control) need to be tested prior to use of the reagents on the evidence or the test results are invalid, (2) any color change at the Kastle-Meyer step should be recorded by time and test result to establish the test result as inconclusive and (c) if the test is not timed correctly after addition of hydrogen peroxide, a positive color reaction will occur anyway, so the test result needs to be read at the 30 second point or the result will be a false positive. Other samples that yield a false positive with this test are plant peroxidases and heavy metals from soils, for example.



HemaTrace – This is an immunochromatographic test that is based on antigen-antibody interaction for detection and confirmation of human blood in crime scene samples. The antigen or target substance for detection is human hemoglobin giving human specificity to the test. The detection method is by human antibody recognition of a target region of human hemoglobin; the antibody is conjugated to a chromagen (color change indicator on binding to antigen). A small amount of sample is hydrated in the buffer provided with the test cartridge to solubilize the human hemoglobin. The liquid sample is loaded into the test well (s) and the sample migrates up the embedded test strip to the second well. Two antibodies are present in this test cartridge, one that is mobile and migrates along with the test sample; the other is fixed in the read region of the cartridge, the (C) and (T) wells. How does this work? The mobile antibody binds to the soluble hemoglobin and migrates to the upper portion of the strip. As the hemoglobin-antibody complex migrates, it is captured by the second antibody which is fixed to the strip and a color change to red is interpreted as a positive confirmation of human blood being present. Quality control for this test is the following: (1) sufficient hemoglobin must be solubilized for the test to detect human blood (incubation is typically 5 minutes in buffer), (2) sufficient liquid must be added to the test cartridge for the sample to migrate up the test strip (20-100ul), and (3) sample must not be too concentrated or the (C) line will not turn the expected positive red, indicating the binding to the second antibody has been blocked by excessive hemoglobin protein in the sample (high dose hook effect)-all of these circumstances will give a false negative reading for the confirmatory test for human blood samples.



This example shows a positive confirmatory test for human hemoglobin which meets the legal standard for testimony for a sample containing human blood. If the test (T) line was absent and the control (C) line present, then the test result would be read as negative for the presence of human blood regardless of whether the presumptive test was positive. The confirmatory test is the most specific test available for human blood identification in casework samples. DNA tests do not replace human blood identification tests as the target substance is a different molecule. Human hemoglobin identification is specific to the substance we know as blood and the only manner in which blood can meet the legal standard for identification in forensic science.

Contextual Contamination of Forensic Evidence by Post-Conviction Litigators

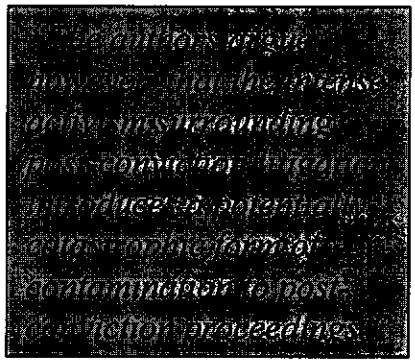
John M. Collins and Jay Jarvis
Crime Lab Report, 1921 W. Wilson Street, Suite A-252, Batavia, IL 60510

May 12, 2009

NOTE: This is the pre-publication draft whose final and definitive form was published in the 2009 Journal of the Institute for the Advancement of Criminal Justice, an annual journal published in cooperation with the California District Attorney's Association.

ABSTRACT

This paper expands on research reported by the authors in a 2009 article titled "The Wrongful Conviction of Forensic Science." Since that study, which was published in *Forensic Science Policy & Management,* additional convictions have been overturned as the result of post-conviction litigation and the use of DNA evidence. Since 1989, over 230 convictions have been overturned. Representatives in the innocence network continue to work diligently to identify wrongfully convicted prisoners and secure their immediate release.



The authors argue, however, that the intense activism surrounding post-conviction litigation introduces a potentially catastrophic form of contamination to post-conviction proceedings. The authors refer to this phenomenon as *contextual contamination,* which is the misapplication of circumstantial information during the legal and judicial interpretation of scientific findings. Because DNA exonerations, as they are commonly called, often occur so long after the original crimes were committed, newly acquired scientific findings, however accurate or valid they may be, can be improperly applied by litigators and judges who fail to consider the full significance and probative value of the forensic evidence.

From the perspective of the forensic science community, contextual contamination has also caused a serious problem outside of the courtroom. An energetic and persistent public policy campaign has been fueled by post-conviction litigation activists who blame faulty forensic science for being a leading cause of wrongful convictions. In this paper, the authors will provide a historical background for this campaign and demonstrate through actual case studies how serious the threat of contextual contamination is to the American criminal justice system and the safety of the public.

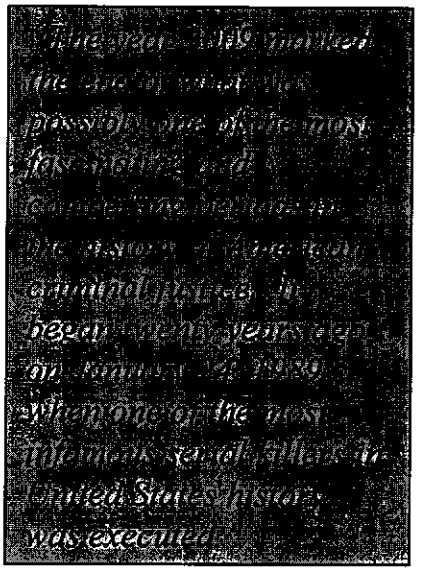
AUTHORS' NOTE

The conclusions and opinions expressed in this paper are solely those of the authors and do not necessarily reflect the views of any persons or organizations with whom the authors are affiliated or employed. The authors also wish to emphasize that they have no

official opinion regarding the guilt or innocence of any individuals discussed in this paper. Readers are strongly encouraged to draw their own conclusions about a case only after they have independently researched all of the available information. The facts surrounding criminal cases such as the ones discussed here are complex and may not be entirely accessible to the public.

1989 – 2009: Twenty Turbulent Years

The year 2009 marked the end of what was possibly one of the most fascinating and compelling periods in the history of American criminal justice. It began twenty years ago on January 24, 1989 when one of the most infamous serial killers in United States history was executed. A crowd of nearly 200 people gathered outside the state prison in Starke, Florida to cheer when they learned that Theodore "Ted" Bundy had died in the prison's electric chair.[1] His execution sent shock waves through a large community of death-penalty opponents whose efforts to convince public policy makers that capital punishment was inappropriate for criminals as violent as Bundy were losing their effectiveness. But only seven months later on August 14, 1989, the tide quickly turned when Gary Dotson became the first man to be released from prison after DNA tests were used to demonstrate his innocence.[2]

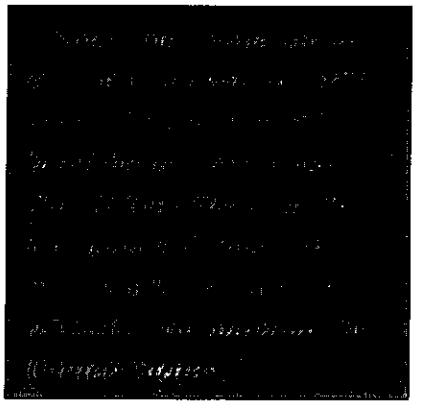


The realization that scientific evidence as robust and reputable as DNA could be used to prove the innocence of wrongfully convicted defendants was a new opportunity that eventually gave birth to the modern innocence movement. Until that time, public opinion over the death-penalty was divided along ideological lines. The resulting lack of a strong public consensus created a heavy burden on those seeking to abolish the death penalty for good. But in the face of new scientific evidence that revealed horrific errors committed by our justice system, it became evident that public support for the death penalty might eventually subside on its own. As a result, the vigorous movement to abolish the death penalty in the United States, which was so active during the decade of the 1980s[3], quickly gave way to a new and more powerful campaign to identify wrongly convicted prisoners and advocate for their immediate release.

The Innocence Network

Beginning in 1993, specialized educational clinics affiliated with law schools and journalism schools throughout the United States (known as Innocence Projects) were established to review the cases of prisoners claiming to be innocent.[4] This concept, made famous by well-known criminal defense attorneys Barry Scheck and Peter Neufeld in New York, has been a successful one. Young students eager to make a difference while learning the nuances of criminal law are able to study actual cases in significant detail within a clinical setting. Further action is taken when a case is identified as having evidence that could realistically demonstrate the innocence of the prisoner. In most

instances, this involves the existence of biological evidence that can be subjected to modern DNA testing techniques.[5] Since the exoneration of Gary Dotson in 1989, over 230 convictions have been overturned due to the efforts of the Innocence Project in New York City and its affiliates throughout the United States.[6]



The authors recognize the overwhelming value of the innocence network and its focus on correcting the human tragedy of wrongful convictions. But in a 2009 article titled *The Wrongful Conviction of Forensic Science*, John Collins and Jay Jarvis chronicled what they described as erroneous public policy rhetoric emanating from several high-profile activists within the innocence network.[7] Much of this rhetoric disparaged the forensic sciences to the extent that reasonable people might be persuaded to distrust the work being performed in America's crime laboratories. But as Collins and Jarvis observed, another factor magnified the problem considerably:

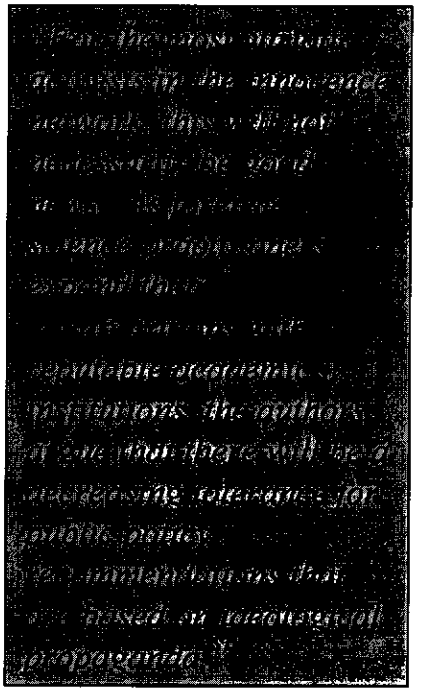
> "To the advantage of many within the innocence network, these statements were rarely, if ever, subjected to any serious examination and were quick to appear as front-page stories in major newspapers throughout the United States. With public enthusiasm for forensic science being so widespread, the notion that it could actually be contributing to the imprisonment of innocent citizens was a story too compelling to ignore."[8]

The National Academy of Sciences Report of 2009

A dramatic close to these twenty turbulent years came in February 2009 when the National Academy of Sciences (NAS) in Washington, D.C. released one of the most anticipated reports in its history titled "Strengthening Forensic Science in America – A Path Forward." Despite how it was characterized in the media, the report was largely the result of cries from the forensic science community calling for an objective evaluation of the profession and the identification of areas where resources were most needed.[9] For years, leaders in the forensic science community advocated for the infusion of funds into the forensic sciences so that laboratories could keep pace with growing demand and research could be conducted to better demonstrate the validity of the most commonly practiced disciplines. Senator Richard Shelby of Alabama was a key proponent. In 2006, he urged the National Academy of Sciences to study the problems facing America's forensic science laboratories and develop ways to help solve them.[10] The result was the creation of the *Committee on Identifying the Needs of the Forensic Science Community.*

Contrary to some perceptions, the committee's historic report did not claim or conclusively demonstrate that the most commonly practiced forensic disciplines were unreliable. In some instances, the report argued quite the opposite. "For decades, the forensic science disciplines have produced valuable evidence that has contributed to the successful prosecution and conviction of criminals as well as to the exoneration of innocent people."[11] The primary concern raised by the report was the "substantial evidence indicating that the level of scientific development and evaluation varies substantially among the forensic science disciplines."[12] In other words, the committee recognized the need for a more robust and accessible body of research that would allow the validity of these disciplines to be verified.

The reason, however, that the NAS report represented the end of such a tumultuous and contentious period was the necessity it created for collaboration and the establishment of good partnerships to ensure that the forensic sciences are given the support that they need. For the most vitriolic activists in the innocence network, this will not necessarily be good news. As forensic science practitioners expand their collaborations with reputable academic institutions, the authors argue that there will be a decreasing tolerance for public policy recommendations that are based on ideological propaganda.



Dr. Roger Kahn is the former president of the American Society of Crime Laboratory Directors and a practicing DNA expert in Texas.[13] He recently remarked about the precedent for science to transcend ideology. According to Kahn, "this clearly happened with DNA after the second report by the National Research Council on DNA testing. It led to important research and publications that resolved a variety of statistical questions in a rigorous manner. In doing so it strengthened the underpinnings of forensic DNA."[14]

Unfortunately, the NAS report of 2009 had a major flaw. Its authors lent credence to accusations that forensic science malpractice and invalid forensic methods are significant causes of wrongful convictions without any authoritative, objective research cited to support those claims. The report noted that "in some cases, substantive information and testimony based on faulty forensic science analyses may have contributed to wrongful convictions of innocent people."[15] It also claimed that "imprecise or exaggerated expert testimony has sometimes contributed to the admission of erroneous or misleading evidence."[16] But no attempt was made to evaluate the frequency and severity of these instances. In light of the fact that erroneous forensic science was presented in the report as a major reason to create a new federal bureaucracy to oversee the forensic science community, it is surprising that the NAS report did not demand a more objective and thorough review of cases where forensic science malpractice is blamed for wrongful convictions and other complications occurring in criminal trials.

Contextual Contamination of Forensic Evidence

It is the opinion of the authors that the blame assigned to faulty forensic science for wrongful convictions is a myth perpetuated by a psychological phenomenon known as *contextual contamination,* which has been shown to complicate psychological experiments by creating inappropriate central-tendencies and anchoring effects.[17] As it applies to the interpretation of forensic evidence, this means that certain circumstances and conditions can cause scientific findings to be misconstrued as confirming guilt or innocence when, in fact, they do not. It also means that forensic evidence and testimony presented at trial can be unfairly characterized as faulty when, in fact, it was not.

It was a hot and humid evening in Burlington, N.C. on July 28, 1984. "Jennifer Thompson, then a 22-year-old college student, went to bed early in her off-campus apartment. As she slept, a man shattered the light bulb near her back door, cut her phone line, and broke in.[18] Thompson awoke to find a man pressing a knife blade to her throat. When she offered the man credit cards, money, and even her car, he simply said 'I don't want your money.'"[19]

As she was being raped, Jennifer Thompson consciously focused on memorizing details about her attacker in the hopes that she would be able to identify him in the future. According to Thompson, she was "just trying to pay attention to a detail, [so] that if I survived, and that was my plan, I'd be able to help the police catch him." [20]

Eventually, she would identify 22-year-old Ronald Cotton, a local restaurant worker with a criminal history of pleading guilty to breaking and entering and sexual assault. Thompson was certain that Cotton was the man who had raped her and it would take only 40 minutes for a jury to agree with her and sentence Cotton to 50 years in prison. Two years later, Cotton would also be convicted of a second rape that occurred around the same time.[21]

After eleven years in prison, DNA evidence helped to reveal Cotton's innocence. It also confirmed the real identity of Jennifer Thompson's rapist, Bobby Poole, who was being held in the same prison as Ronald Cotton for a separate offense. In fact, their physical appearances were so similar that inmates frequently mistook Cotton for Poole and vise versa. But it was during the coverage of the O.J. Simpson murder trial in 1995 that Ronald Cotton learned about DNA evidence and began his own crusade to conclusively prove that his conviction was erroneous.[22] Jennifer Thompson and Ronald Cotton, who are now friends, work collaboratively to help raise awareness about the risks of eyewitness identifications.[23]

By all accounts, the conviction of Ronald Cotton was overwhelmingly fueled by the certainty of the victim in her identification of Cotton. During the trial, Thompson pointed to Cotton and affirmed "Cotton is the man who raped me."[24] The only forensic evidence presented to jurors in the case, however, was "a piece of foam found [at the crime scene] that seemed to come from one of his shoes."[25] Investigators later determined that the material was consistent with a pair of athletic shoes worn by Ronald Cotton – but inconsistent with material in Jennifer Thompson's shoes.

Despite the fact that "the foam rubber could have come from any one of a thousand athletic shoes in Almanac County, the possibility that it might have matched one of Ronald Cotton's shoes provided police reason to believe [that it may be a link] to the perpetrator." [26] Perhaps this is why the Innocence Project, as in many other cases, lists "invalid or improper forensic science"[27] as a contributing cause of Ronald Cotton's conviction.

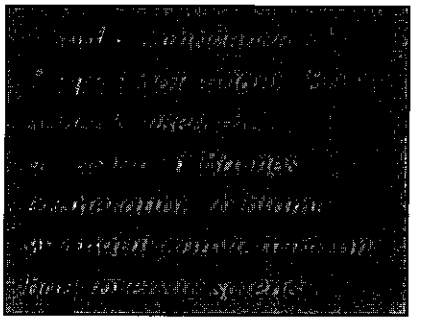
What is troubling about those who blame faulty forensic science for Cotton's conviction is their apparent lack of interest in whether the foam rubber was actually consistent with Ronald Cotton's shoes. Indeed, from a scientific perspective, this would be the primary consideration in determining whether or not the forensic evidence was improper. It would also matter whether or not the significance of the evidence was exaggerated during the trial. But no indication was found in the public record that such an instance of malpractice occurred. This includes summaries of the Ronald Cotton case published by the Innocence Project[28], the Center on Wrongful Convictions at

Northwestern University[29], and the website for the Department of Justice's DNA Initiative.[30] The fact that DNA evidence was eventually used to demonstrate Cotton's innocence has no bearing on the validity of any forensic tests that were presented at his trial.

The Steven Barnes Case

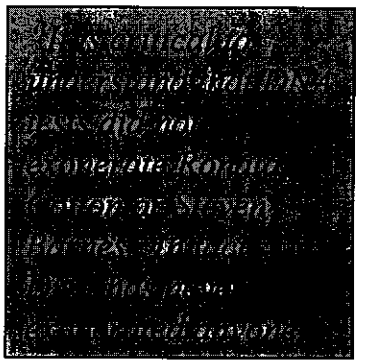
Another high-profile case that became distorted by the Innocence Project was the conviction and exoneration of Steven Barnes. "Barnes was convicted in 1989 for the rape and murder of Kimberly Simon, whose body was found four years earlier near the Mohawk River in upstate New York."[31] He was released from prison on January 9, 2009 when DNA testing "yielded conclusive results on sperm cells from the victim's body and clothing – none of which matched Barnes."[32]

Forensic evidence presented by the prosecution during Barnes' trial included soil samples collected from the tires of Barnes' truck, which were similar to soil samples collected from the crime scene.[33] "Expert testimony was also given that an imprint on the outside of the same truck was ***similar*** to the fabric pattern of a particular brand of jeans worn by the victim when she was killed."[34] In a commentary published on February 18, 2009 by Crime Lab Report, it was noted that one of the lead forensic examiners who testified in Barnes' trial stated emphatically "that the soil and fabric-pattern evidence were non-specific and could not be used to identify the perpetrator."[35]



Sadly, Innocence Project cofounder, Barry Scheck, used the occasion of Barnes' exoneration to blame wrongful convictions on bad forensic science. "This is the latest in a long line of wrongful convictions based on improper or invalid forensic science that were ultimately overturned through DNA testing," Scheck noted. "Until there are clear national standards about what kind of forensic science can be allowed in court, more people like Steven Barnes will be wrongfully convicted while the actual perpetrators of violent crime remain at large."[36]

DNA Activism – An Emerging Threat to Public Safety

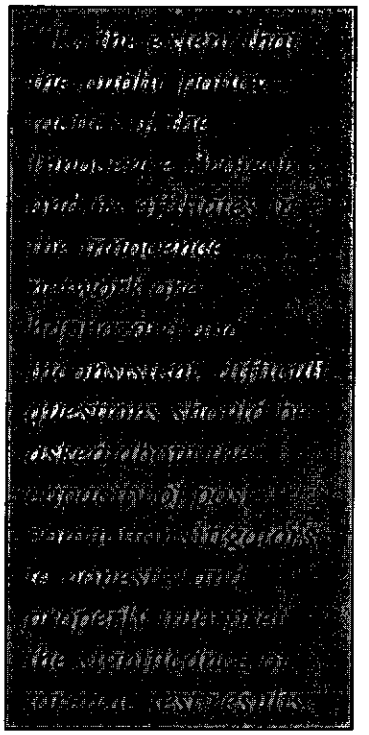


It is critical to understand that DNA tests did not exonerate Ronald Cotton or Steven Barnes. In fact, DNA has never exonerated anyone. In the Barnes case, for example, it was the compelling arguments made by Innocence Project representatives, who first took on his case in 1993, that the DNA tests were proof of innocence.[37] The foundation of this argument necessarily rested on the assumption that the sperm cells recovered from the victim were deposited as a direct result of her rape. Any possibility that they were deposited prior to the rape as a result of consensual sex with another partner would have to be ruled out in order for the DNA tests to be interpreted as evidence of factual innocence. In many cases, this may depend entirely on the word of the victim.

Forensic science is incapable of determining guilt or innocence. The term DNA exoneration, used so frequently by journalists who report on overturned convictions, is a misnomer. DNA does not exonerate innocent prisoners – people do. As the Ronald Cotton and Steven Barnes cases demonstrate, very critical and sensitive leaps of logic are needed to cross the line that divides a DNA test result from the confirmation of innocence. Even though DNA results may seem intuitively exculpatory, extreme caution must be exercised. For this reason, the use of DNA evidence to overturn previous convictions is a profoundly serious matter that should be left to the devices of equally serious professionals.

In a 2001 interview of Innocence Project cofounder Peter Neufeld, which was aired by University of California Television, host Harry Kreisler asked Neufeld what "kept him going" despite the toll that his civil rights work must take on his personal life. Neufeld's answer was revealing:

> "The real thing is a desire to see things change. And to the extent that [a] case can have an impact on affecting the minds of just twelve people, not just about this case, but perhaps prospectively changing their outlook on justice, on racism, on the drug wars, on sexism, and on all kinds of issues is something that's terrific to be a vital part of." [38]



In professional environments where scientific thinking is deemed critical to achieving successful and reliable outcomes, the desires that Neufeld explained are considered to be a dangerous contextual bias. In the world of science, efforts to change the status quo simply for the sake of change are risky when such efforts are not guided by reliable research or the thoughtful consideration of alternative hypotheses.

In a 2006 article published in *Forensic Science International*, researchers Itiel Dror, David Charlton, and Ailisa E. Peron of the School of Psychology at the University of Southampton warned of the dangers of bias in searching for the truth. They explained that "professionals must be able to dissociate themselves from extraneous contexts and other influences that may interfere with their ability to examine, evaluate, and judge the relevant information."[39]

To the extent that the public policy tactics of the Innocence Project and its affiliates in the innocence network are haphazard and inconsistent, difficult questions should be asked about the capacity of post-conviction litigators to honestly and properly interpret the significance of forensic test results. Furthermore, intense desires to seek exonerations should be construed as a contextual bias that requires due caution to be exercised. As Judge Morris Hoffman pointed out in an article published by the Chicago-Kent Law Review in 2007:

> "Sadly, the empirical literature on wrongful convictions is itself woefully infected with the mythology of factual innocence. Part of the problem, of course, is definitional. How does one determine factual innocence after the system—whose whole purpose is

supposed to be truth-finding—has determined, whether by plea or trial, that a defendant is in fact guilty? This is the mother of all confirmation bias problems." [40]

The Rape and Murder of Sharra Ferger

The potential injustices that can result from the misinterpretation of post-conviction forensic evidence were thankfully, by all accounts, avoided after the tragic death of a beautiful nine-year-old girl in Pasco County, Florida. "On October 3, 1997, nine year-old Sharra Ferger was lured out of her... home late at night and found murdered the next day. On the night she was abducted, she was wearing a green T-shirt she often wore to bed. She was stripped from the waist down. Two men then took turns raping her, one viciously biting her shoulder. They also scratched and beat her. She was then stabbed 46 times, 9 times in the head."[41]

Garry Cannon, 17, was convicted for the murder but could not be executed due to his age at the time of the crime. According to a report in the *St. Petersburg Times*, Cannon was linked to the crime through DNA evidence. A second perpetrator, Sharra's uncle, Gary Cochran, 39, would plead guilty a year later.[42]

What makes this case so instructive was the potential for a wrongful exoneration if the circumstances had been just a bit different. The only forensic evidence linking Cannon to the murder was DNA evidence. Cochran's role, on the other hand, was confirmed by the comparison of his dental impressions to a deep bitemark found on Sharra Ferger's shoulder. But if DNA tests had not initially linked Cannon to the murder, and if Cochran had been convicted based on the bite-mark evidence, Cochran might later have been exonerated when subsequent DNA tests revealed that he, in fact, was not the contributor of biological evidence collected from Ferger's body. Based on what is known now, this could have been a wrongful exoneration resulting from the contextual contamination of the forensic evidence.

One could argue that this scenario is unreasonable because Cochran would likely have snitched on Cannon. But if this case had occurred prior to DNA testing and if Cannon made a compelling claim of innocence, it may have been difficult to link Cannon to the crime, particularly if he was excluded as the contributor of the bitemark on the victim's shoulder. All of these complex nuances illustrate that post-conviction forensic evidence must be treated with the same degree of care and caution as evidence used during trial. As the 2003 exoneration of Steven Avery in Wisconsin demonstrates, the stakes can be a matter of life and death.

From Exoneration to Murder – The Steven Avery Case

In 2003, eighteen years after he was convicted for "the brutal attack of a woman jogging on a beach near Two Rivers, Wis.,"[43] Steven Avery was exonerated when a judge determined that DNA tests were conclusive proof of his innocence. But in 2007, Avery would be convicted of murder and sentenced to life in prison with no chance of parole. "You are probably the most dangerous individual ever to set foot in this courtroom," Judge Patrick Willis remarked. "From what I see, nothing in your life suggests that society would ever be safe from your behavior."[44]

Two years before his murder conviction, Avery became "the first Wisconsin prisoner freed by the . . . Wisconsin Innocence Project, which used DNA tests to link another man to the assault that put Avery in prison."[45] But in considering his sentence

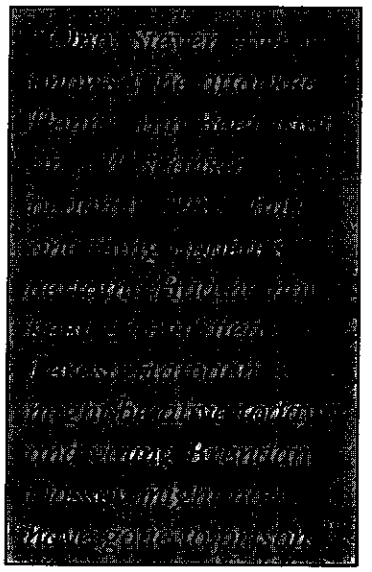
for the murder conviction, Judge Willis "reviewed Avery's history of convictions for burglaries, threatening a woman with a gun and dousing a cat with gasoline before throwing it in a bonfire, before sentencing him. The offenses escalated over time, Willis said, and the latest one – [the murder of Teresa Halbach] - was a 'calculated' case of premeditated murder."[46]

According to reports on the Teresa Halbach murder, Avery bound and gagged his victim and then invited his young learning-disabled nephew, Brendan Dassey, to sexually assault her:

> "Dassey had told the investigators that, after getting off his school bus Oct. 31, 2005, he took mail to Avery's trailer. There, Avery invited Dassey to have sex with Halbach, who was handcuffed, shackled and screaming. Dassey went home briefly, then returned, stripped, raped Halbach, then, after a discussion with Avery, helped bind and stab her before the pair took her to a garage where Avery shot her. After that, according to the confession, the pair burned her body in a pit."[47]

In the rape case for which Avery served eighteen years before being exonerated, the victim, Penny Ann Beernsten, described what happened to her along a beautiful stretch of Lake Michigan beach in 1985. Beernsten would later identify Avery in a lineup.[48]

> "It happened in a beautiful place. I was out jogging when a man grabbed me from behind and pushed me into a wooded area. When I screamed, he choked my windpipe; when I fought back as he tried to rape me, he began beating and strangling me. Finally I lost consciousness. My last thoughts were: 'I wish I'd kissed my son goodbye this morning' and 'my daughter's last vision of me will be of my dead, beaten body.'" [49]



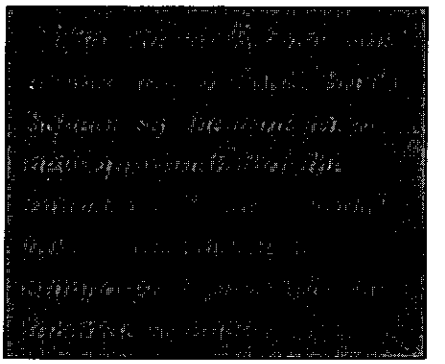
Avery was eventually exonerated when his DNA was excluded as being the same as biological samples recovered from Beernsten.[50] But what if the DNA was not deposited during the initial attack? After all, Penny Ann Beernsten had been strangled and slipped into unconsciousness. What if Avery was, in fact, the initial attacker but failed to ejaculate? What if he then invited an accomplice to sexually assault Beernsten while she was unconscious – just like he allegedly did in the Teresa Halbach murder?

Penny Ann Beernsten is now an advocate for reforming eyewitness identification procedures. But as is the case with all post-conviction DNA testing, the most defendants can hope for is to be excluded as the contributor of biological evidence. Science cannot confirm innocence. Thoughtful and knowledgeable people must look at the totality of the evidence and decide for themselves what the post-conviction forensic tests actually mean. We can only hope that the Avery exoneration was not the result of contextual contamination, but rather a careful and collaborative examination of the evidence.

Only Steven Avery knows if he attacked Penny Ann Beernsten on a Wisconsin beach in 1985, but one thing appears certain. Had he not been exonerated, Teresa Halbach might be alive today and young Brendan Dassey might not have gone to prison. It is possible that strict national standards and better professional oversight are needed to

govern post-conviction litigation practices. But an even higher priority should be placed on providing specialized training to criminal justice professionals in the investigative interpretation of forensic evidence. Unlike the image portrayed by modern television programs, forensic scientists are rarely given access to all of the facts in criminal cases. For this reason, they cannot be relied upon to judge the relationships that exist between forensic testing results and circumstantial facts gathered by investigators. Scientists can certainly be helpful in the process, but ultimately judges and lawyers must fully and properly evaluate forensic evidence before and after a conviction.

The Innocence Project Changes its Strategy



After Steven Barnes was exonerated in 2008, Barry Scheck set the tone for a new approach that the Innocence Project would take in advancing its campaign to discredit the forensic sciences. According to Scheck, "Unvalidated and exaggerated science convicted Steven Barnes and cost him nearly two decades, but real science finally secured his freedom."[51] This statement represented a significant departure from the previous strategy of blaming wrongful convictions on what Scheck and his organization repeatedly termed *faulty forensic science* or *unreliable/limited science*. But after the authors reported on the Innocence Project's mischaracterization of forensic science as often being faulty, there was a new effort by Barry Scheck and Peter Neufeld to characterize various forensic disciplines and practices as simply being *invalid*.

This new tactic of blaming wrongful convictions on *invalid science* provided the Innocence Project with an escape hatch that did not exist before. Because their previous attempts to blame wrongful convictions on *faulty forensic science* were demonstrated to be erroneous, the more subjective interpretation of forensic evidence as being *invalid* would be easier for them to defend – not because forensic science disciplines are actually invalid, but because innocence activists could simply create a definition of *validity* that suited their own purposes.

As Barry Scheck's comment following the Barnes exoneration suggested, the primary strategy now being employed by the Innocence Project is to hold DNA up as the standard for valid forensic science – or as Scheck opined, a "real science." The basis for this strategy, however, is illogical and caters to the layperson's lack of knowledge about DNA testing.

DNA Testing in Proper Perspective

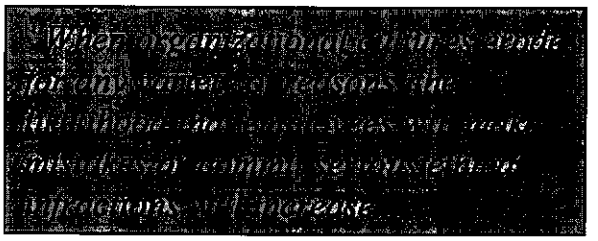
Forensic DNA testing can be used effectively to demonstrate the innocence of wrongfully convicted prisoners when it is employed responsibly and case circumstances leave unanswered questions about the origin of biological evidence. In most overturned convictions, DNA testing was not feasible at time of the original trials. Therefore, DNA provides an opportunity to undue miscarriages of justice even years after they were committed. But the recent strategy of anointing DNA as a standard of science that other traditional forensic disciplines fail to meet is grossly unfair and not based in reality.

DNA results are statistical in nature, so they are often perceived as being more scientific. DNA profiles are sets of numbers that can be easily entered into a spreadsheet and lend themselves quite nicely to being searched through complex databases. Probabilities can then be established and reported to express the likelihood that a particular DNA profile will occur randomly in particular segments of the human population. Unfortunately, there is a common misconception that these probabilities represent rates of error, which was famously magnified in 1993 by the United States Supreme Court in its landmark decision in *Daubert v. Merrell-Dow Pharmaceuticals, Inc.*[52] But in many ways, the testing of DNA is very similar to its other forensic cousins such as latent print identification or firearm identification (ballistics). Education, training, expertise, and professionalism are needed to properly interpret all scientific evidence – including DNA. The actual rate of error in the practice of forensic DNA testing is currently not known.

Understanding Forensic Science Malpractice

Systemic failures in forensic science happen from time to time just as they do in other critical professions.[53] But the authors have come to learn through first-hand experiences as accreditation inspectors[54] and directors of internationally accredited forensic science laboratories[55] that they are almost always a symptom of an organizational deficiency, not junk science. These weaknesses can be repaired with improved management practices, improved levels of funding to meet demand for services, and better overall methods for managing quality. The 1996 National Academy of Sciences report on DNA testing acknowledged that a key element of quality assurance is "the responsibility of laboratory managers for all aspects of laboratory operations and performance, including definition and documentation of standards for personnel training, procedures, equipment and facilities, and performance review." [56] When organizational cultures erode for any variety of reasons, the likelihood that employees will make mistakes or commit serious ethical infractions will increase.

Roughly three million cases are submitted to publicly funded crime laboratories each year costing taxpayers approximately 1.1 billion dollars.[57] The percentage of these laboratories that achieved accreditation status grew from 71% in 2002 to 82% in 2005.[58]



"Of all laboratories currently accredited by the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB), 73 percent achieved accreditation for the first time after 1992."[59] The vast majority of the 232 wrongful convictions studied by the authors of this paper occurred prior to 1989 when forensic science accreditation had yet to revolutionize practices in forensic science laboratories.

Based on the current annual case volume, if publicly funded forensic science laboratories had an overall failure rate of 0.01%, which would be an impressive record of quality in any service industry, the total number of cases involving some sort of forensic science malpractice would still amount to a disturbing 300 cases each year. But consider a hypothetical scenario in which 1000 erroneous laboratory results go undetected by

laboratories, investigators, and trial courts – and – where the malpractice contributes directly to a wrongful felony conviction. Although this is a grossly unreasonable scenario in the opinion of the authors,[60] the chance that one of the 3 million cases worked by forensic science laboratories in the United States each year would directly result in a wrongful felony conviction would be approximately 0.0003% - or three ten-thousandths of a percent.

Recent Data in Overturned Convictions

Each wrongful conviction inflicts horrific pain on the victims and their families. For this reason, exonerations tend to elicit a prompt response from local journalists and strong emotional reactions from the relevant community. These emotions are to be expected; however, they do not necessarily allow for a clear and thoughtful examination of wrongful convictions or an accurate diagnosis of their causes.

There are new signs that journalists are beginning to re-examine the complexities of wrongful convictions in the United States. In January 2009, the Richmond Times-Dispatch reported that the Urban Institute, "a 40-year-old organization that studies social and economic issues to promote sound public policy and effective government," [61] was awarded $300,000 by the Department of Justice to examine the causes of wrongful convictions. In the *Times-Dispatch* report, a quote from Brandon Garrett, a professor of law at the University of Virginia, was included to put the complexity of post-conviction litigation in perspective. According to Garrett, "wrongful-conviction cases are harder to study, much less generalize about."[62]

With this in mind, the authors examined the 201st through 232nd convictions overturned by the innocence network. In keeping with the methodology and principles published in "The Wrongful Conviction of Forensic Science," each case was studied to determine the role of forensic evidence at the original trial. In several instances, trial transcripts were available for review.[63] The following tables provide a summary of this examination:

Table 1: Original convictions attributed solely to witness misidentification

Number of Cases: 11 of 32
Percent of Cases: 34%

					EVALUATION OF FORENSIC EVIDENCE		
Exoneree	***State***	***Incident***	***Exonerated***	***Transcripts***	***Exculpatory***	***No Bearing or Nonspecific***	***Malpractice***
Travis Hayes[64]	LA	1998	2007	Yes	X		
James Waller[65]	TX	1983	2007	Yes	X		
John Jerome White[66]	GA	1980	2007	Yes		X	
Gregory Wallis[67]	TX	1989	2007	Yes		X	
Marcus Lyons[68]	IL	1988	2007	No		X	
Steven Phillips[69]	TX	82-83	2008	No		X	
Andrew Gossett[70]	TX	2000	2007	No		X	
Patrick Waller[71]	TX	1992	2008	No		X	
Robert McClendon[72]	OH	1991	2008	No		X	
Arthur Johnson[73]	MS	1993	2008	No		X	
Thomas McGowan[74]	TX	85-86	2008	No		X	

Summary of the Forensic Evidence: In two cases, the convictions of Travis Hayes and James Waller, the forensic evidence was exculpatory. Hairs recovered from bed sheets were shown to exclude James Waller. In 8 of the above 11 cases, the conviction was not supported by the forensic evidence. In the conviction of John Jerome White, forensic scientist Benny Blankenship testified that hair samples recovered from the crime scene "could have come" from White. But under both direct and cross-examination, he clearly explained that only similarities were observed and that he could not conclusively identify White as the contributor of the hairs. The

defense attorney questioned Blankenship repeatedly about the significance of the evidence which yielded testimony indicating the state of the art was not sufficient to make conclusive identifications.

Table 2: Original conviction attributed solely to an informant / snitch

Number of Cases: 1 of 32
Percent of Cases: 3%

					EVALUATION OF FORENSIC EVIDENCE		
Exoneree	*State*	*Incident*	*Exonerated*	*Transcripts*	*Exculpatory*	*No Bearing or Nonspecific*	*Malpractice*
Chad Heins[75]	FL	1996	2007	Yes	X		

Summary of the Forensic Evidence: In the trial of Chad Heins, hairs recovered from the crime scene were eliminated as having come from Heins.

Table 3: Original convictions attributed solely to false / coerced confessions

Number of Cases: 2 of 32
Percent of Cases: 6%

					EVALUATION OF FORENSIC EVIDENCE		
Exoneree	*State*	*Incident*	*Exonerated*	*Transcripts*	*Exculpatory*	*No Bearing or Nonspecific*	*Malpractice*
James Dean[76]	NE	1989	2007	No		X	
Debra Shelden[77]	NE	1989	2007	No		X	

Summary of the Forensic Evidence: Information regarding these two cases was limited. It appears, however, that false or coerced confessions were the primary contributing factors leading to the convictions.

Table 4: Original convictions with multiple causes – not supported by forensic evidence

Number of Cases: 5 of 32
Percent of Cases: 16%

					EVALUATION OF FORENSIC EVIDENCE		
Exoneree	*State*	*Incident*	*Exonerated*	*Transcripts*	*Exculpatory*	*No Bearing or Nonspecific*	*Malpractice*
James Curtis Giles[78]	TX	1983	2007	Yes		X	
Ronald Gene Taylor[79]	TX	1995	2008	Yes		X	
Dean Cage[80]	IL	1996	2008	No		X	
Jerry Miller[81]	IL	1982	2007	No		X	
Willie Williams[82]	GA	1985	2007	Yes		X	

Summary of the Forensic Evidence: In the above five cases, forensic evidence was limited and/or nonspecific to the point that it had no significant role in demonstrating the guilt of the defendant.

Table 5: Original convictions attributed to multiple causes – nonspecific forensic evidence presented by prosecution as evidence of possible guilt.

Number of Cases: 11 of 32
Percent of Cases: 34%

					EVALUATION OF FORENSIC EVIDENCE		
Exoneree	*State*	*Incident*	*Exonerated*	*Transcripts*	*Exculpatory*	*No Bearing or Nonspecific*	*Malpractice*
William Dillon[83]	FL	1981	2008	No		X	
Charles Chatman[84]	TX	1981	2008	Yes		X	
Steven Barnes[85]	NY	1989	2009	No		X	
Rickie Johnson[86]	LA	1983	2008	Yes		X	
Nathaniel Hatchett[87]	MI	1998	2008	Yes		X	
Joseph White[88]	NE	1989	2008	No		X	
Ada Taylor[89]	NE	1989	2009	No		X	
Thomas Winslow[90]	NE	1989	2009	No		X	
Kathy Gonzales[91]	NE	1989	2009	No		X	
Michael Blair[92]	TX	1994	2008	Yes		X	
Byron Halsey[93]	NJ	1988	2007	Yes		X	

Summary of the Forensic Evidence: With the exception of one case, the above convictions were associated with very weak or non-specific forensic evidence that could not conclusively associate or exclude the defendants. In the trial of William Dillon, dog scent

tracking evidence was presented at trial and may have been presented as being more reliable than it actually is. But because dog scent tracking is not a forensic science, it was dismissed for the purposes of this study. In the case of Steven Barnes, exculpatory fingerprint evidence was presented as well as nonspecific pattern and soil comparisons.

Table 6: Original convictions attributed to forensic science malpractice

Number of Cases: 2 of 32
Percent of Cases: 6%

					EVALUATION OF FORENSIC EVIDENCE		
Exoneree	***State***	***Incident***	***Exonerated***	***Transcripts***	***Exculpatory***	***No Bearing or Nonspecific***	***Malpractice***
Curtis McCarty[94]	OK	86-89	2007	Yes			X
Kennedy Brewer[95]	MS	1995	2008	Yes			X

Summary of the Forensic Evidence: The malpractice cases shown in the above table are clear and convincing instances of forensic science malpractice. In the conviction of Kennedy Brewer, erroneous bitemark testimony was offered by Dr. Michael West, who at the time of the trial, had already been suspended from the American Board of Forensic Odontology for previous malpractice. But the court allowed his testimony despite his professional troubles. The conviction of Curtis McCarty, however, was one of several cases associated with the infamous Joyce Gilchrist who has been implicated in several instances of forensic science malpractice. It must be noted that neither of these convictions involved testimony from scientists who conducted their work in accredited forensic science laboratories.

Updated Data Tabulations for 232 Exonerations

When the data collected during this study are added to the previous tabulations previously reported by the authors, the following breakdown of the role of forensic science in overturned convictions can be examined:

Table 7: The role of forensic science – by number and percent of cases [96]

Rank	Percent	Cases	Description
1	36%	83	Non-specific science failed to exclude the defendant
2	33%	76	Conviction was not supported by forensic evidence
3	17%	39	Forensic evidence was favorable to the defendant
4	15%	34	Forensic science malpractice
		232	

Table 8: Probable systemic failures in 232 convictions – by number and percent [97]

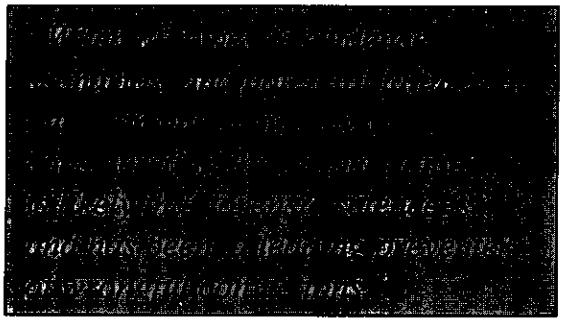
Rank	Percent	Instances	Description
1	55%	174	Eyewitness misidentification
2	15%	47	False confessions
3	**11%**	**34**	**Forensic science malpractice**
4	9%	30	Government misconduct
5	9%	28	Informant snitches
6	1%	4	Bad lawyering
		317	

Discussion

As discussed earlier, forensic science malpractice of a significant nature is rare and is unlikely to contribute to a wrongful conviction even when it does occur. At the time the authors wrote "The Wrongful Conviction of Forensic Science," only one wrongful conviction had been associated with an instance of forensic science malpractice occurring in an accredited laboratory. As the authors observed:

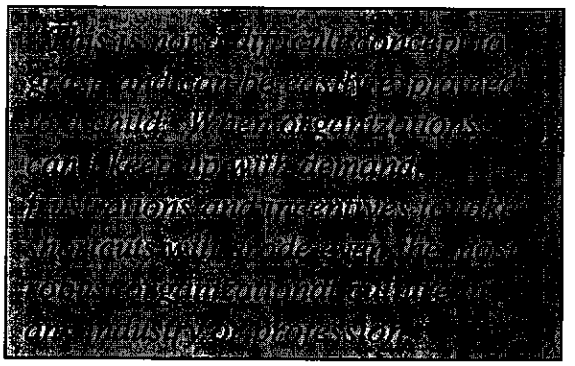
". . . it was a false exclusion of a rape victim's husband as being the contributor of semen found on a rape-kit swab and bedding from the victim's home. The error did not directly incriminate the defendant. Also, the incident occurred in 1988 when crime laboratory accreditation was in its infancy."[98]

Forensic science methods applied in laboratories accredited by the American Society of Crime Laboratory Directors / Laboratory Accreditation Board (ASCLD/LAB) are subjected to so many checks and balances that the possibility that a catastrophic error or ethical violation would go undetected by both the laboratory's quality management system and the adversarial scrutiny of a trial court is extremely low.



Unfortunately, critics seeking to micromanage the forensic sciences with new bureaucracies and politically charged oversight schemes are unwilling to accept accreditation as a reliable, stand-alone system of quality control. Even worse, evidence that accreditation *does* work - the enhanced ability of accredited laboratories to identify failures – is irresponsibly mischaracterized as evidence that accreditation *doesn't* work. A laboratory that is able to look critically at its own operations and identify problems is a cause for celebration, not punishment. The internal mechanisms of self-assessment combined with the external mechanisms of peer-assessment must be allowed to find and correct weaknesses without the risk of reprisal. If the basic principles of quality control and quality assurance in forensic science become contaminated by politics and the natural inclination of activists to punish what they perceive as wrongdoing, society can expect the forensic science infrastructure in the United States to collapse under its own weight.

When all types of evidence, scenarios, and potential failures in our criminal justice system are considered in the proper context, it is likely that forensic science is, and has been, a leading *preventer* of wrongful convictions. All criminal justice institutions have a certain capacity to process incoming cases with a finite number of people and resources to get the job done reliably. It is a mistake to think that these institutions operate differently than other types of organizations. If an automotive manufacturing plant, for example, attempts to keep pace with a level of demand that is unmanageable given its current rate of staffing and capitalization, it will be more likely to assemble bad cars. If an accountant is faced with more tax returns than what he or she can handle in a given year, his or her filings to the IRS are more likely to have errors.



This is not a difficult concept to grasp and can be easily explained to a child. When organizations can't keep up with demand, frustrations and incentives to take shortcuts will erode even the most robust organizational culture in any industry or profession. Certainly, this is not an excuse for gross malpractice or unethical behavior.

Such instances cannot be tolerated and must be met with severe consequences. But it is also unethical to deprive prosecutors, public defenders, forensic scientists, and police officers of the resources they need to do their jobs completely and reliably. Who steps in to confront this kind of negligence? Ultimately, it falls on our elected leaders and their constituents to ensure that our criminal justice system has the resources it needs to work reliably and efficiently.

Summary and Conclusions

Eyewitness misidentifications continue to rank as the top factor contributing to wrongful convictions in the United States. No other factor comes close in terms of its collective impact on our justice system. It cannot be underestimated how important it is to accurately and completely tabulate the causes of wrongful convictions before assigning a specific share of the blame to any of them. Future studies subjected to the proper kind of peer review with sufficient transparency must look closer at overturned convictions to determine exactly how they happen and if, in fact, apparent instances of forensic science malpractice can be fairly labeled as such.[99] It is hoped that the work of the Urban Institute and other independent researchers will succeed in this endeavor. But the authors warn that political wrangling and activism will contaminate the process and bring discredit to any useful conclusions that are rendered as a result of such studies.

Ultimately, the causes of wrongful convictions are really symptoms of a larger problem. It is the disease that needs to be cured. In the long run, public resources will be better spent on helping to improve the talent base and organizational cultures of our justice institutions. Strong organizations with strong leaders supported by talented, motivated employees are much less likely to make serious mistakes. In this regard, lawyers and judges should pay close attention to the management practices of crime laboratories serving their jurisdiction. Junk science is not a systemic problem in our criminal justice system. Struggling organizations, however, burdened by increasing demand and dwindling resources *are* a systemic problem.

The next twenty years will hopefully bring new solutions. And if all goes well, the entire criminal justice system will improve its competence at evaluating forensic evidence and ensuring that contextual distortions are not allowed to contaminate criminal proceedings or public policy discussions related to the use of science in our search for justice.

Acknowledgements

The authors would like to extend their sincere thanks to Lauren Hoshimoto for her invaluable efforts in compiling the news reports and contact information needed to complete this project. We would also like to thank our families – Mary, Debra, Kevin, Karen, John, and James - who, since 2004, have been patient in allowing us to serve the public by offering a more informative and accurate analysis of the issues facing the forensic science community.

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[53] The most publicized and infamous instances of malpractice were associated with a small number of individuals (Fred Zain, Joyce Gilchrist, Pamela Fish) who did not work in accredited laboratories.
[54] The authors are both trained and practicing volunteer accreditation inspectors serving ASCLD/LAB.
[55] John Collins is the Director of the DuPage County Crime Laboratory in Wheaton, IL. Jay Jarvis served as the director of the Georgia Bureau of Investigation laboratory in Summerville, GA. Both laboratories are accredited under the international ISO 17025 standard for calibration and testing laboratories. The opinions and views expressed in this paper do not necessarily reflect those of any organizations or persons with whom the authors are affiliated.
[56] United States, National Academy of Sciences (NAS), The Evaluation of Forensic DNA Evidence (Washington: 1996) p.78
[57] United States, Bureau of Justice Statistics, Census of Publicly Funded Forensic Crime Laboratories, 2005 (Washington: 2008)
[58] United States, Bureau of Justice Statistics. 2008
[59] Collins and Jarvis. 2009. p. 28
[60] According to Judge Morris Hoffman in his article "The Myth of Factual Innocence," the federal plea bargaining rate is 96.3%. The state plea bargaining rate is 95%. To have 1000 cases in one year in which forensic science malpractice directly contributes to a wrongful conviction is statistically unreasonable.
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[89] See note 79

[90] See note 79

[91] See note 79

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[96] For the purposes of this table, the Steven Barnes case was listed as a conviction with non-specific science although exculpatory forensic evidence was presented at his trial. Additional research is underway to look more carefully at the cases being attributed to forensic science malpractice. Significant uncertainty exists regarding the number of cases that should actually be labeled as such.

[97] Additional research is underway to look more carefully at the cases being attributed to forensic science malpractice. Significant uncertainty exists regarding the number of cases that should actually be labeled as such.

[98] Collins & Jarvis. 2009. p.28

[99] Collins & Jarvis. 2009. p.26

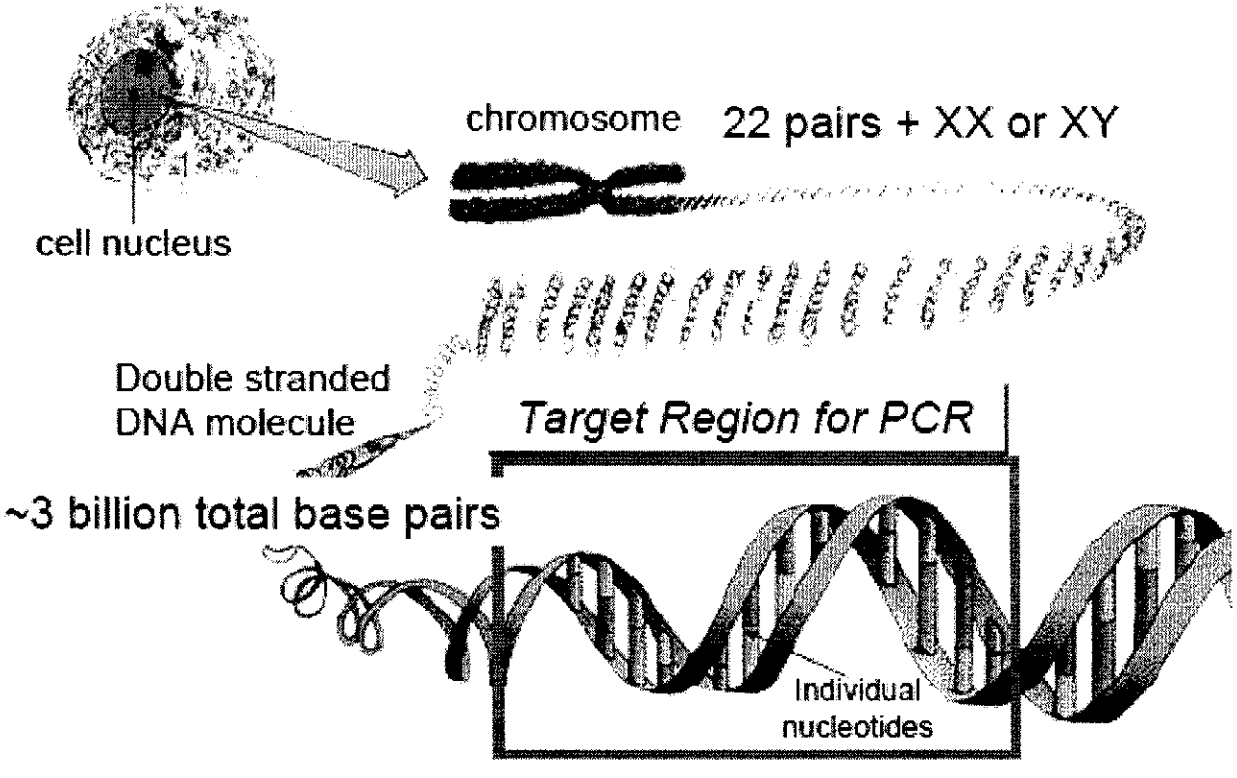
DNA

HEATHER MILLER COYLE, PH.D.
IDENTACODE CONSULTING LLC

DNA FACTS

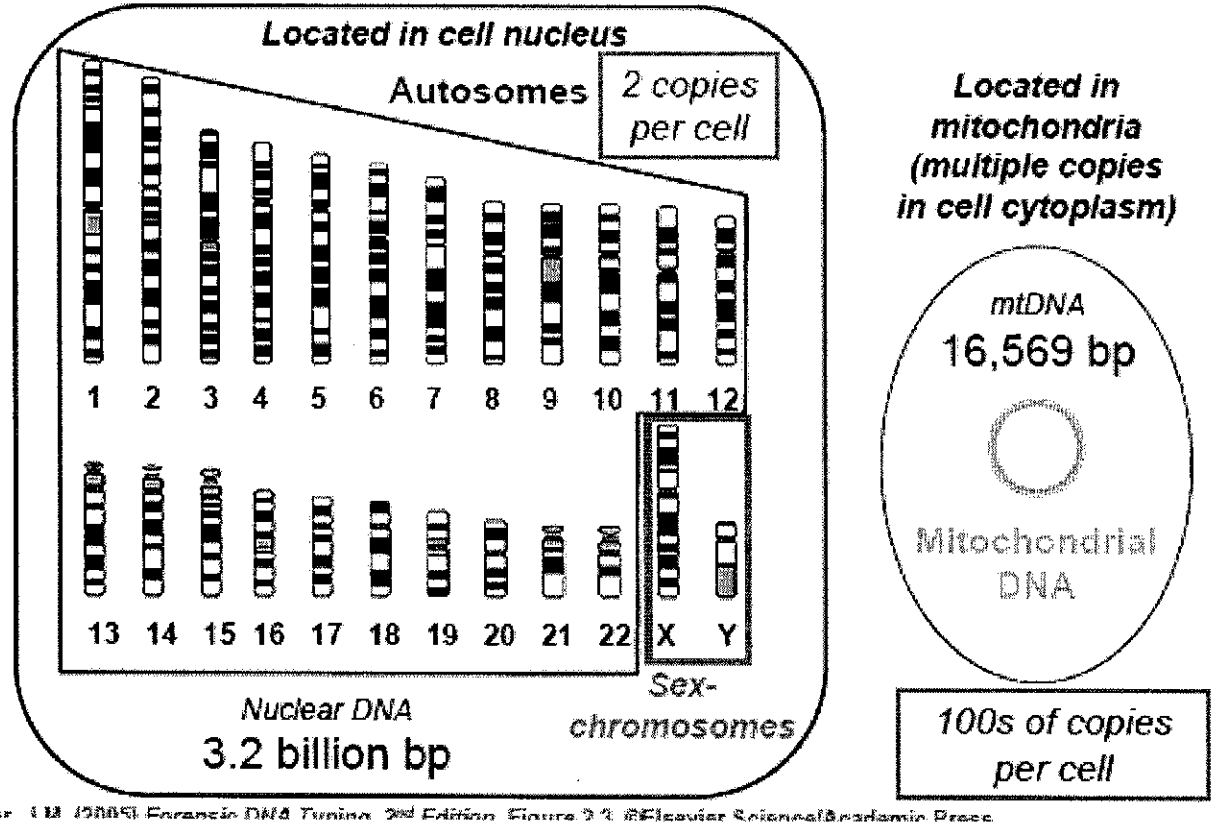
- DNA is found in every living organism
- DNA is not variable in different tissues so a profile from blood is the same as a profile from semen
- Most DNA is nuclear or part of the 23 pairs of chromosomes found in a cell – in nucleus
- Another form of DNA is found in cells called mitochondrial testing – in cytoplasm
- Genetic relatives share more of their DNA than unrelated individuals

DNA in the Cell



Human Genome

23 Pairs of Chromosomes + mtDNA



Butler, J.M. (2005) Forensic DNA Typing, 2nd Edition, Figure 2.3, ©Elsevier Science/Academic Press

EACH TARGET IS ON SEPARATE CHROMOSOMES

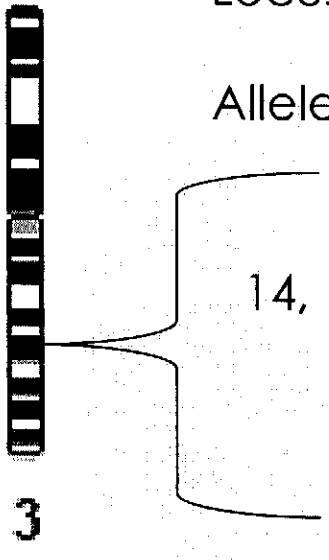
GLOSSARY

- Chromosome – DNA structure in nucleus
- Locus (plural loci) – position on chromosome
- Allele – variation at each locus
- Shared DNA
  - By genetic inheritance - % correlates to relationship
  - By coincidence - % is random (10 – 75%)
- Low copy number DNA – less than 1ng
- High sensitivity testing – additional PCR cycles

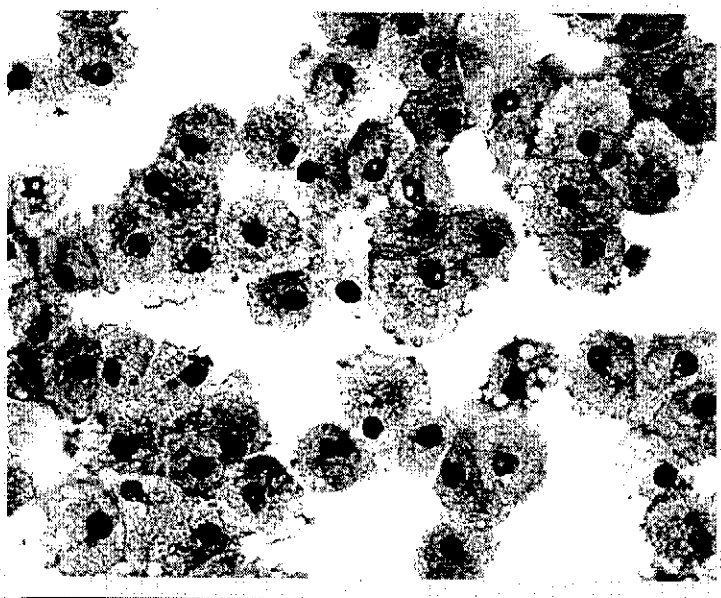
LOCUS VS. ALLELE

Locus – a position on the chromosome

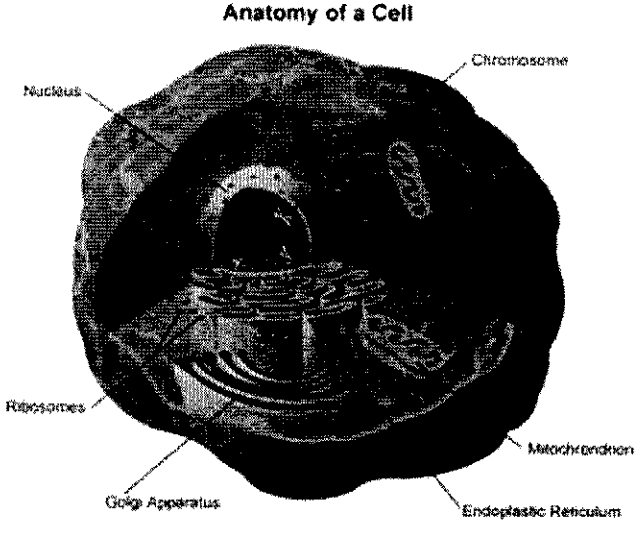
Allele – alternate forms found in a population



The combinations of alleles yield an individual profile if single source. Mixtures are much more complicated with greater chance of coincidental match as more individuals are added to profile.



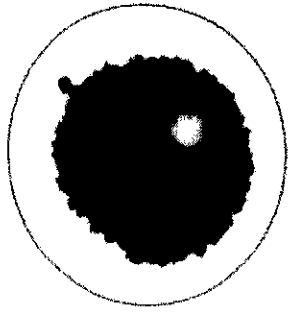
1 ng for DNA



HOW MUCH DNA IS THERE IN A CELL?

APPROXIMATELY 6 PICOGRAMS

ESTIMATES OF DNA



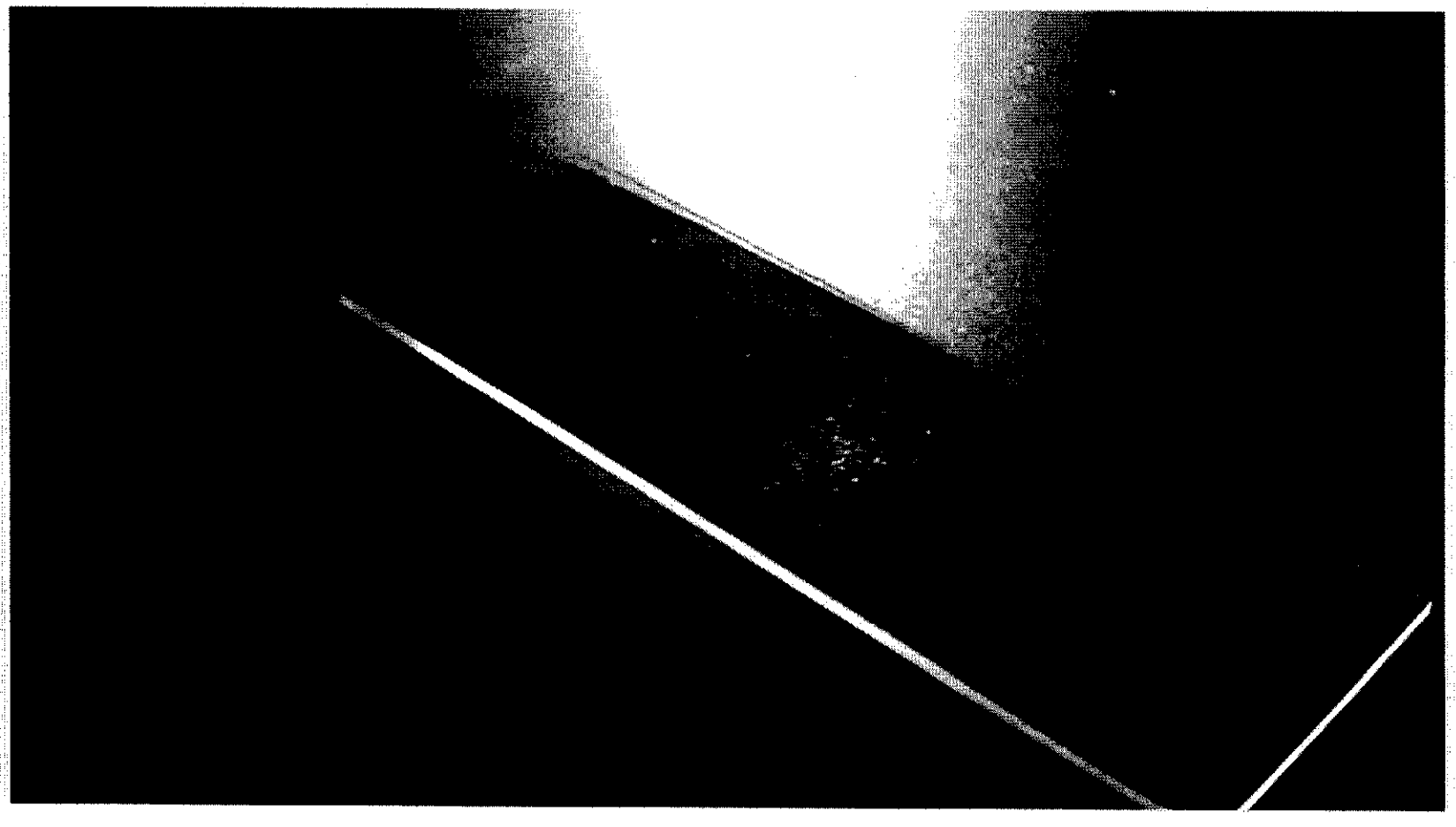
Blood Stain

Table 1. DNA content of biological samples[a]

Type of sample	Amount of DNA
Liquid blood	20,000-40,000 ng/mL
stain	250-500 ng/cm^2
Liquid semen	150,000-300,000 ng/mL
Postcoital vaginal swab	10-3,000 ng/swab
Hair (with root)	
Plucked	1-750 ng/root
Shed	1-10 ng/root
Liquid saliva	1,000-10,000 ng/mL
Oral swab	100-1500 ng/swab
Urine	1-20 ng/mL
Bone	3-10 ng/mg
Tissue	50-500 ng/mg

[a]Quantity of DNA recovered from evidentiary samples is significantly affected by environmental factors.

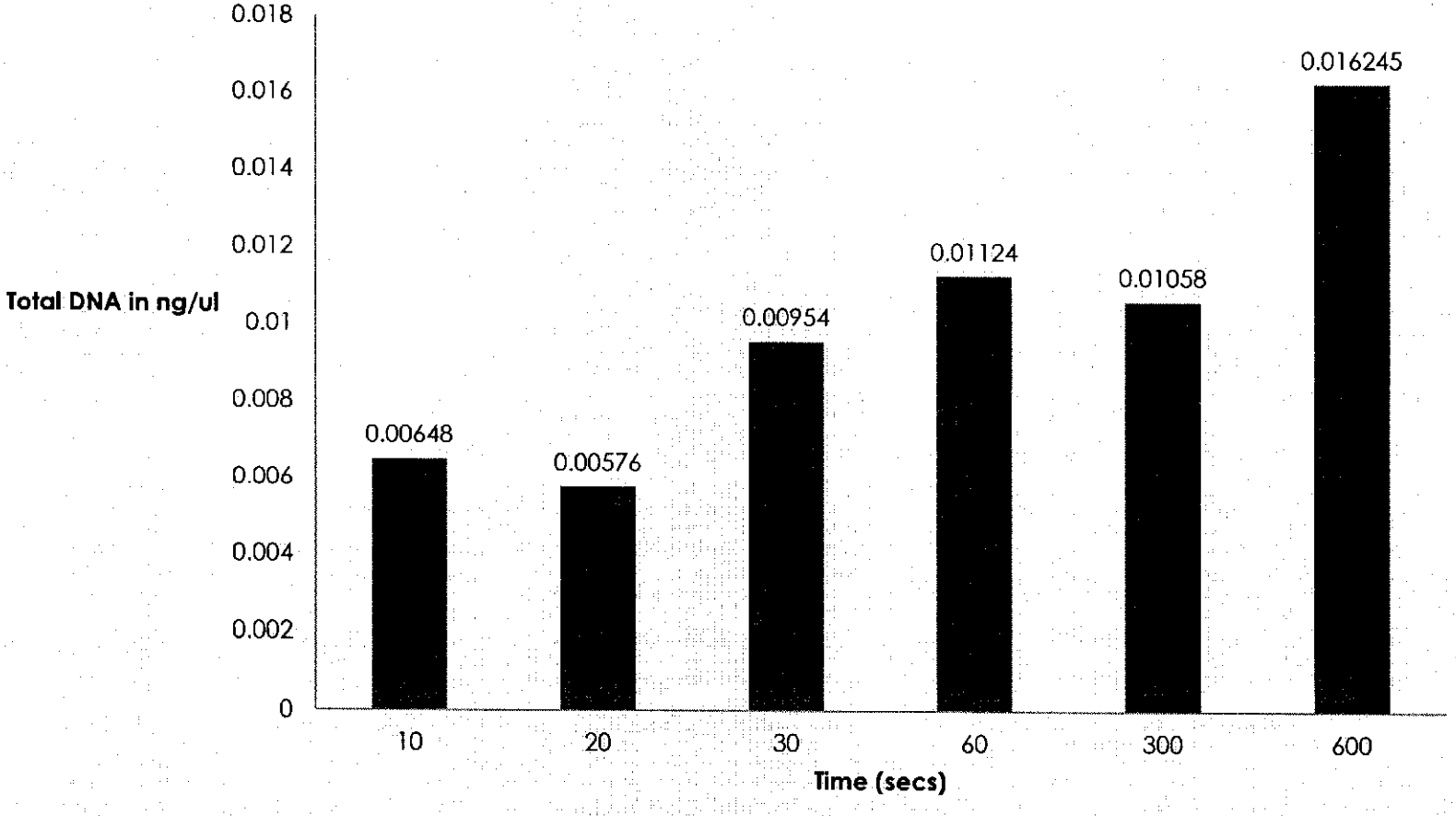
Lee, HC and Ladd, C. 2001. Preservation and Collection of Biological Evidence. Croatian Medical Journal. 42(3): 225 - 228.



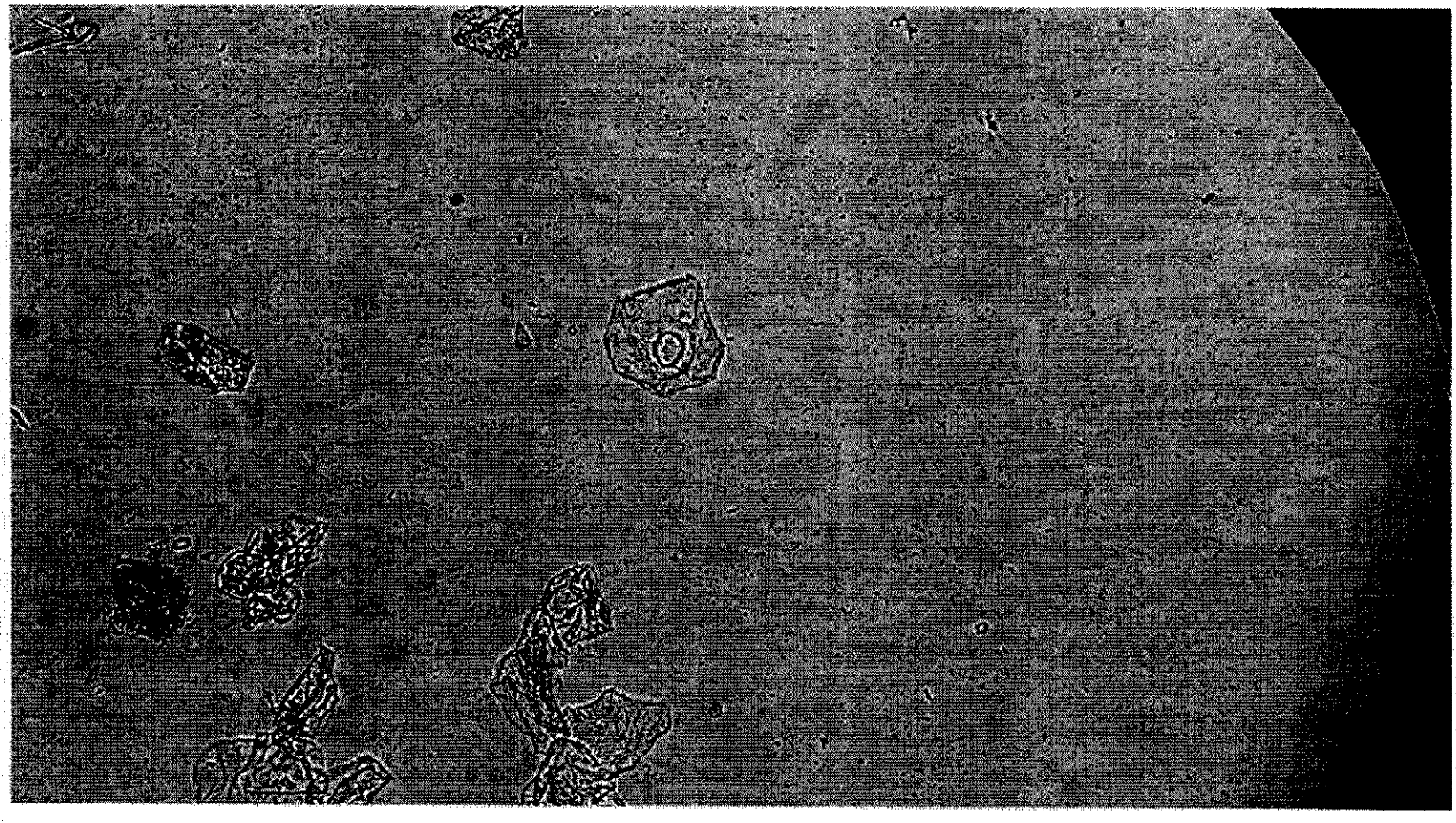
HOW LONG DO YOU HAVE TO TOUCH AN OBJECT TO TRANSFER DNA?

MINIMUM OF 30 SECONDS OF PRESSURE

Smithen, M. 2013. Low Copy Number DNA: Reliable, Robust or Problematic? UNH Thesis.



DNA TRANSFER INCREASES WITH CONTACT TIME



WHERE DOES TOUCH DNA COME FROM?

KERATINOCYTES – CELLS AND PERSPIRATION

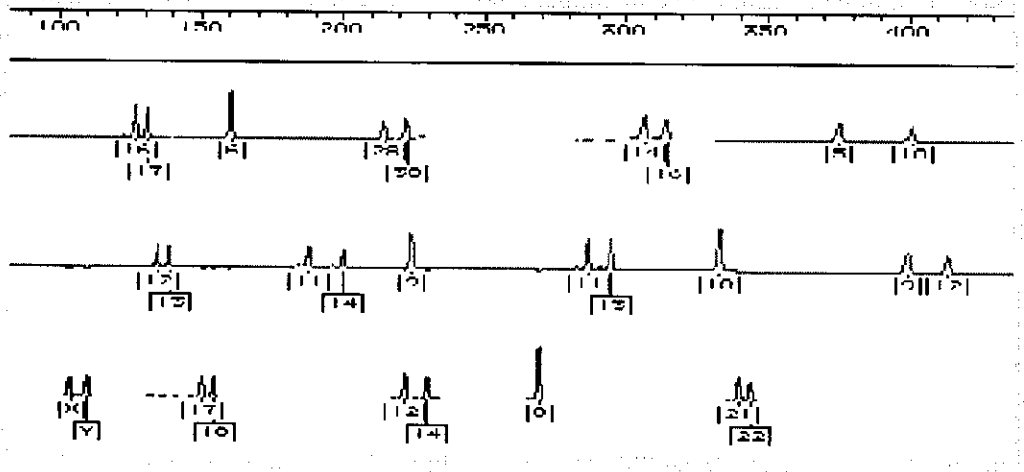
HOW MANY CELLS LEFT BEHIND IN TOUCHING AN OBJECT?

Category	Shedder (> 50 cells/thumbprint)	Non-Shedder	Cell Count Range	01 T	02 W	04 TH
Thumbprint	18	5	2 – 1050+	X		
Thumbprint	19	4	15 – 800+		X	
Thumbprint	20	4	12 – 320+			X
Buccal			79 – 4000+	X		
Buccal			15 – 1580+		X	
Buccal			48 – 272+			X

The data here represents three replicate trials of data collection for 30 seconds of pressure applied to a glass slide with a thumb. The cell counts represent the estimated number of cells from a single thumbprint observed by light microscopy and nuclear fast red staining. Due to programmed cell death or shedding of epithelial cells, only some of the thumbprint cells contain DNA (partially nucleated). As you can see from the data, it is possible to leave a few cells after the contact time but not have a sufficient number to generate a DNA profile. Keep in mind; since the average person is shedding thousands of cells off their body every day, it is fairly easy to contaminate your evidence with just a few skin cells if you do not practice good laboratory collection and testing technique. On average, 19% of our study group is classified as non-shedders; 81% are shedders (n = 70). The average number of cells required to generate a DNA profile by standard test methods is 5 – 20 nucleated cells.
Cell counts from buccal swabs are totaled as a comparison and all of these cells contain a nucleus. This is why buccal swabs are the standard for forensic collection of known reference samples.

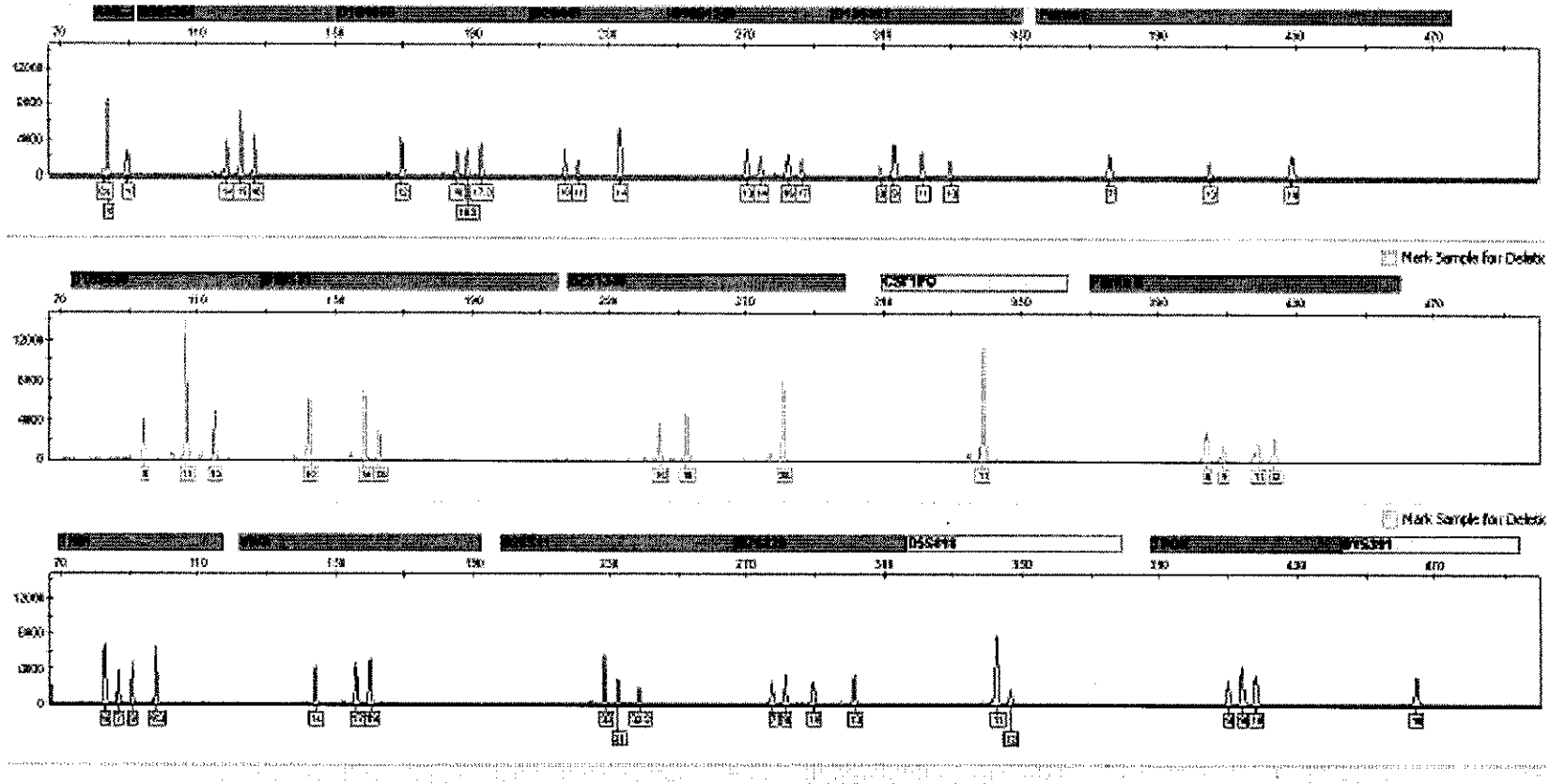
DNA TRANSFER

- Primary transfer – direct deposit on an object
- Secondary transfer – indirect contact via second object
- Contamination – inadvertent addition of DNA to a sample
- Single source sample – DNA from 1 individual
- DNA mixture – DNA from multiple individuals



single source profile

SOURCING TO AN INDIVIDUAL



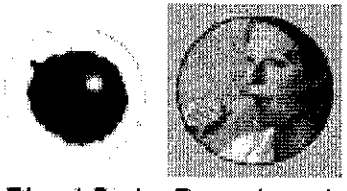
mixture

Steps Involved

- Collection
- Specimen Storage
- Extraction
- Quantitation
- Multiplex PCR
- STR Typing
- Interpretation of Results
- Database Storage & Searching
- Interpretation of Mixtures/Probability

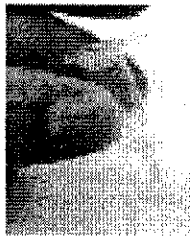
Steps in DNA Analysis

Usually 1-2 day process (a minimum of ~5 hours)

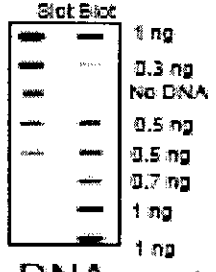


Blood Stain Buccal swab

Sample Collection & Storage



DNA Extraction



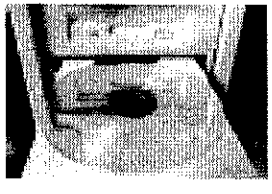
DNA Quantitation

Biology

Multiplex PCR Amplification

Genetics

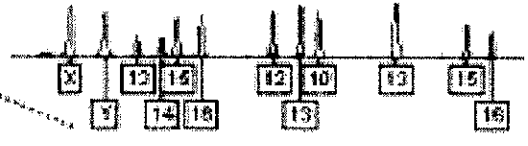
If a match occurs, comparison of DNA profile to population allele frequencies to generate a case report with probability of a random match to an unrelated individual



DNA Database Search

Technology

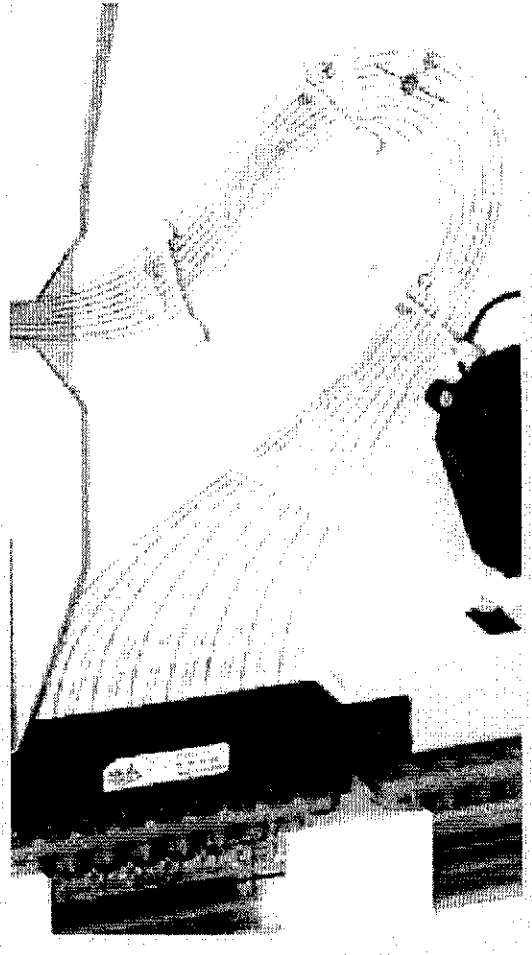
DNA separation and sizing

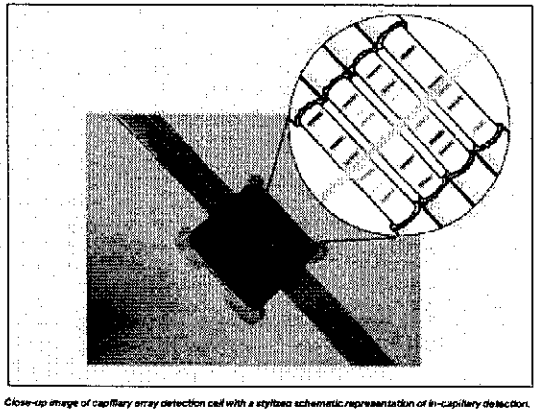


STR Typing

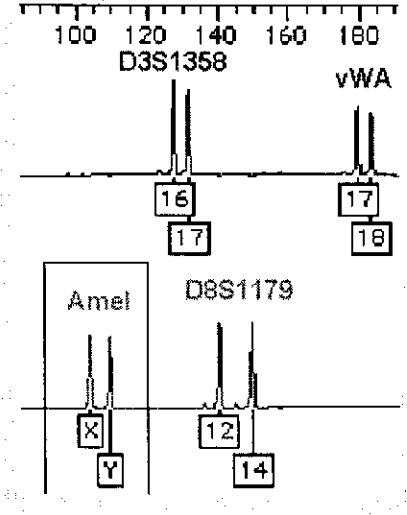
Interpretation of Results

DNA DETECTION & ANALYSIS





Close-up image of capillary array detection cell with a stylized schematic representation of in-capillary detection.

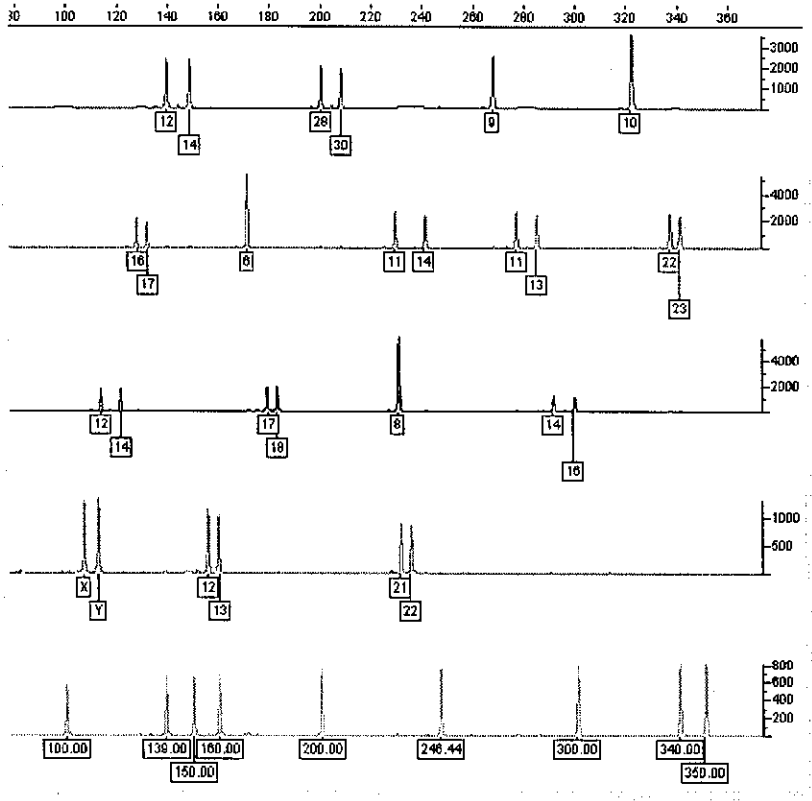


GeneMapper® *ID* Software Versions 3.1and 3.2

Human Identification Analysis

Tutorial

Applied Biosystems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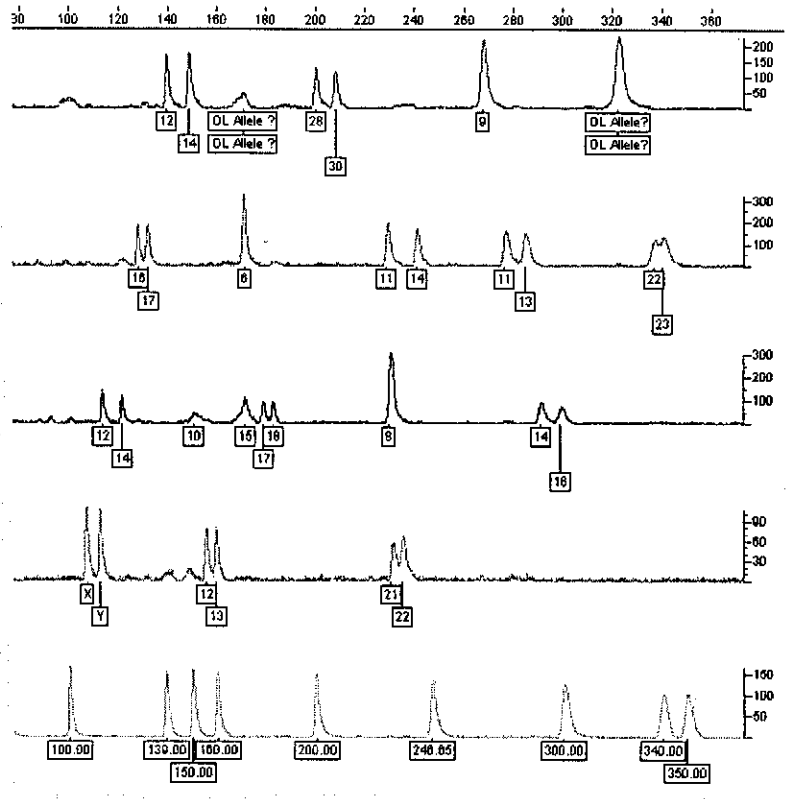
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DNA QUALITY

OCME REPORT CONCLUSIONS

Conclusions for DNA Typing

Is the source of: The DNA profile of an individual matches an evidentiary DNA profile and the population frequency of the evidentiary DNA profile meets the threshold of 1 in greater than 6.80 trillion, assuming the source is not an identical twin.

Could be the source of: The DNA profile of an individual is consistent with an evidentiary DNA profile, and the population frequency of the evidentiary DNA profile does not meet the threshold of 1 in greater than 6.80 trillion unrelated people.

Is a major or minor contributor to the mixture: The DNA profile of an individual matches a major or minor evidentiary DNA profile determined from a mixture, and the DNA population frequency of the determined major or the minor DNA profile meets the threshold of 1 in greater than 6.80 trillion individuals, assuming that source is not an identical twin.

Could be a major or minor contributor to the mixture: The DNA profile of an individual is consistent with a major or minor evidentiary DNA profile determined from a mixture, and the DNA population frequency of the determined major or the minor DNA profile does not meet the threshold of 1 in greater than 6.80 trillion unrelated people.

Could be a contributor to the mixture: For mixtures where individual profiles were not determined, all of the DNA alleles seen in an individual's DNA profile were also seen in the mixture for the locations where comparisons could be made.

Cannot be excluded as a contributor to the mixture: For the locations where comparisons could be made, most of the DNA alleles seen in an individual's DNA profile were also seen in the mixture. The allele(s) that were absent could be explained by any of several factors. Therefore, this person cannot be ruled out as a possible contributor to the mixture.

Excluded as a contributor to the mixture: For the locations where comparisons could be made, one or more of the DNA alleles seen in an individual's DNA profile were not seen in the mixture and this absence cannot be explained. Therefore, this person can be ruled out as a contributor.

No conclusions can be drawn: For the locations where comparisons could be made, the results do not support a positive association or an exclusion. Therefore, it cannot be determined whether a person contributed to this mixture.

Not suitable for comparison: The DNA results on the evidence are either too incomplete or too complex to be the basis for conclusions regarding the source of the DNA.

ERROR RATES

- Error – defined as incorrect information in the final report
- 63% forensic testing (in general)
- 1.2% or 12/1000 tests in DNA study (Austin, TX)
- Approximately 1 in 100 cases

- Forensic Scientists Make Errors. Source: Saks & Koehler, 309 *Science* 892 (2005)
- P. Walsh. 2002. False result fear over DNA tests. The Observer.

SOURCES OF ERROR

- *Contamination*
- Poor technique – published studies on standard DNA testing show most contamination is from surfaces in a lab or from the analyst rather than aerosol (DNA transfer by air)

- Toledano, T. et al. 1997. An Assessment of DNA Contamination Risks in New York City Medical Examiner Facilities. JFS. 42(4): 721 – 724.
- Scherczinger, C. et al. 1999. A Systematic Analysis of PCR Contamination. JFS. 44(5): 1042 – 1045.

SOURCES OF ERROR

- *Reporting*
- Incorrect statements in report or at trial
- Transcription errors and typos

- *Interpretation*
- Assessment of the data is incorrect in lab
- Contextual contamination

CONTEXTUAL CONTAMINATION

HEATHER MILLER COYLE, PH.D.
IDENTACODE CONSULTING LLC

CONTEXTUAL CONTAMINATION

- Misapplication of circumstantial information during legal and judicial interpretation of scientific findings
- Identified as a key component to many exoneration cases
- This can work in both a positive and negative manner in cold case evaluation and in post-conviction casework
- Alternate hypothesis training is one way to minimize targeting an individual with the science in an inappropriate manner

Table 7: The role of forensic science – by number and percent of cases [96]

Rank	Percent	Cases	Description
1	36%	83	Non-specific science failed to exclude the defendant
2	33%	76	Conviction was not supported by forensic evidence
3	17%	39	Forensic evidence was favorable to the defendant
4	15%	34	Forensic science malpractice
		232	

EXAMINATION OF 232 EXONERATION CASES

COLLINS, J. ET AL. 2009. CONTEXTUAL CONTAMINATION OF FORENSIC EVIDENCE BY POST-CONVICTION LITIGATORS. CRIME LAB REPORT 1-20.

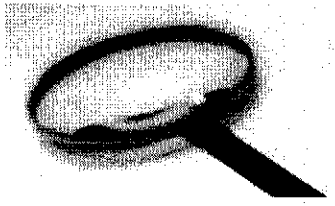
EXAMPLES

- North Carolina vs. George Goode Jr. - 1993
- North Carolina vs. Samuel McCullum – 2007

- Both of these cases had unusual features and circumstances with case evidence
- Both had issues with biological testing and interpretation of the results
- North Carolina system has been subject to both independent review and review at request of Attorney General – major overhaul of their forensic laboratory system (estimated error rates of 1.5 – 3%)

NORTH CAROLINA VS. GEORGE GOODE JR. - 1993

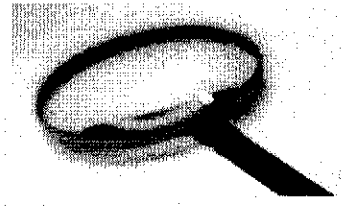
ORIGINAL CASE DETAILS



- 1993
- Double homicide
- 4 individuals involved
- 2 of the individuals were brothers
- 3 of the individuals had blood-soaked clothing indicating closer contact to the victims during the brutal stabbings

- George Goode, Jr.
- Has always claimed no direct involvement of the case
- No prior criminal history
- Claimed they were out previously, then dropped by his place; while he was inside, his brother and the 2 other individuals assaulted and killed his landlords
- He walked over, became a witness, his brother handed him an object and he walked away
- All 4 individuals were apprehended shortly thereafter

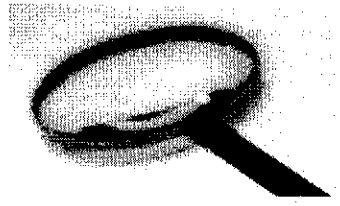
ORIGINAL CASE DETAILS



- 1993

- All 4 individuals were tried separately as if each one had performed the stabbing personally and each given the death penalty
- Mr. George Goode Jr. became controversial due to the complete absence of human blood identified on his clothing
- Mr. Goode's case has taken some very surprising turns from 1993 to 2013 and when placed in context of a fraudulent system, now looks very different than it did originally
- Relief thus far, conversion of death sentence to life in 2010

ORIGINAL CASE DETAILS



- 1993
- Examination of Mr. Goode's boots and coveralls
- Two tests for blood on the coveralls were negative
- In fact, the original case file specifically describes the stains as "grease" on the lower portion of the front leg area

- The criminalist examined his boots for "invisible" blood – what does that mean? Pristine blood can appear differently than diluted blood stains
- The soles of the boots were negative
- The top left boot had a presumptive spot of possible blood but it was never confirmed in testing
- In trial transcripts, the word "blood" was mentioned over twenty times to the jury giving the very strong impression that Mr. Goode was covered in blood or up to his ankles in blood – neither of which were true
- The judge and jury heard a complete misrepresentation of the scientific weight of presumptive blood testing at trial

1993 CASE NOTES - BOOTS

NCSBI Serology Section
Lab Notes

LAB FILE NO. R925956 16

SBI 120

EM NO. 31

PACKAGING:
[ ] SEALED BROWN PAPER BAG
[ ] SEALED ENVELOPE
[ ] OTHER:

CONTAINING: E 56pb 1 pair of military style black boots
No visible blood

RESULTS OF TESTING:

[ ] Not examined

Attach photos, sketches, or drawings here.

IDENTIFICATION OF BLOOD:
+ - PHENOLPHTHALEIN very slight Left boot
ONS - TAKAYAMA can't see any spots
(Enter results as + (Pos), - (Neg) or Inc.)

IDENTIFICATION OF SPECIES:
_____ - HUMAN CONTROL
_____ - ANTI -HUMAN
_____ - RABBIT SERUM
_____ - SUBSTRATE CONTROL
(Enter results as + (Pos), - (Neg) or Inc.)

RESULTS OF ABO TESTING _____
(See separate testing sheets)

IDENTIFICATION OF SALIVA:
_____ TEST SAMPLE
_____ KNOWN CONTROL
_____ REAGENT BLANK
_____ SUBSTRATE CONTROL
_____ ABSORBANCE READING
(Enter results on a scale from - to +++)

IDENTIFICATION OF SEMEN (AP TEST):
_____ TEST SAMPLE
_____ KNOWN CONTROL
_____ REAGENT BLANK
_____ SUBSTRATE CONTROL
(Enter results on a scale from - to +++)
_____ P30 test (+ or -) - see other forms

SAMPLES TO:
[ ] ELECTROPHORESIS [ ] DNA

Deaver Notes
11/93

1993 CASE NOTES - COVERALLS

SBI
130

NCSBI Serology Section
Lab Notes

LAB FILE NO. R925956 18

ITEM NO. 32b

PACKAGING :
[ ] SEALED BROWN PAPER BAG
[ ] SEALED ENVELOPE
[ ] OTHER _____

CONTAINING : a pair of green dirty greasy Overalls

RESULTS OF TESTING:

[ ] Not examined

Attach photos, sketches, or drawings here.

IDENTIFICATION OF BLOOD :
_____ PHENOLPHTHALEIN
NFA - TAKAYAMA
(Enter results as + (Pos), - (Neg) or Inc.)

IDENTIFICATION OF SPECIES.
_____ - HUMAN CONTROL
_____ - ANTI-HUMAN
_____ - RABBIT SERUM
_____ - SUBSTRATE CONTROL
(Enter results as + (Pos), - (Neg) or Inc.)

RESULTS OF ABO TESTING _____
(See separate testing sheets)

Deaver Notes
George's coveralls (same as overalls)

32(b) Bisette Notes
Pre-trial
(-) Pheno

32b pair of dark green overalls
numerous dark stains - grease
no obvious reddish brown stains
Pheno (-)

ORIGINAL
SEROLOGY
REPORT

SB165

26

R920005956

RESULTS OF ANALYSIS (CONTINUED):

Item	ABO	PGM	PGMsub	EsD	Hp	PepA	Hb	Consistent With Blood Of
#8 (absorbed samples)	NT	1	1+	5-1	qns	qns	A	Leon Batten
#9 (absorbed samples)	NT	2-1	Inc	1	qns	qns	A	Margaret Batten
#10 (absorbed samples)	NT	2-1	Inc	1	qns	qns	A	Margaret Batten
#11 (absorbed samples)	NT	2-1	Inc	1	qns	qns	A	Margaret Batten
#12 (absorbed samples)	NT	1	1+	5-1	qns	qns	A	Leon Batten
#2CG (coat)	NT	Inc	1+	5-1	1	1	A	Leon Batten
#3CG-A (T-shirt)	NT	1	1+	5-1	qns	qns	A	Leon Batten
#3CG-B (polo shirt)	NT	1	1+	5-1	1	1	A	Leon Batten
#3EC (jacket)	NT	1	Inc	5-1	1	1	A	Leon Batten

NT = Not Tested Inc = Inconclusive Results qns = Quantity not sufficient

Human blood was detected on Items #17A, #3-T, and #29 (one hundred dollar bill, knife, tennis shoes); however, the quantity was insufficient for further analysis.

No blood was detected on Items #32a, #32b, #32c, #32d, #1EC, #2EC-A, #2EC-B, #4EC, #5EC-A, #5EC-B, and #6EC (sweat pants, overalls, boxer shorts, camouflage hat, overalls, pants, jockey shorts, tennis shoes, shirt, shirt, jacket).

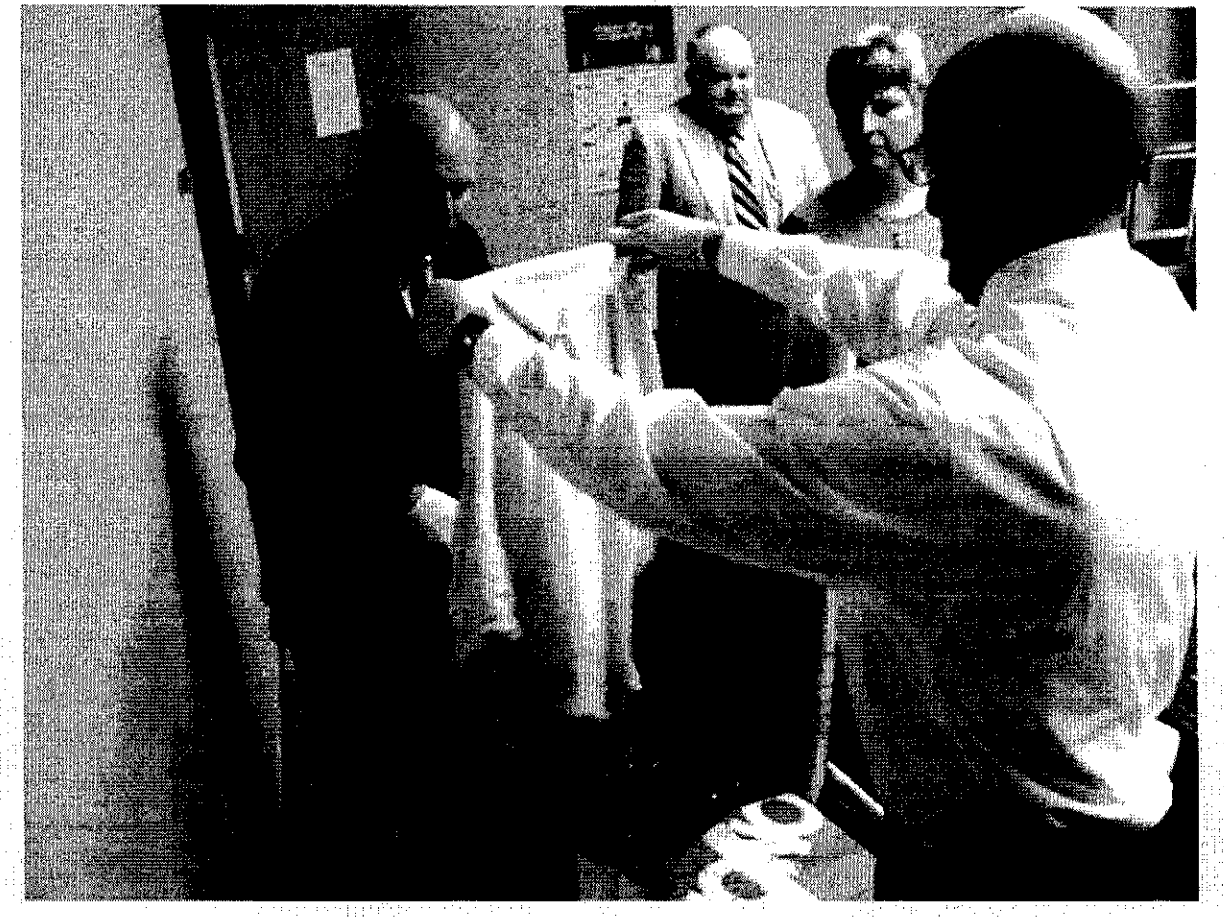
Microscopic examination of the vaginal smears, rectal smears and oral smears (Items #24b, #24e, #24g) failed to reveal the presence of spermatozoa. Analysis of the swab specimens (Items #24c, #24f, #24h) and the panties (Item #24d) failed to reveal the presence of any semen.

DISPOSITION OF EVIDENCE:

The evidence submitted is being returned via United Parcel Service.

BKB:cs
Attachment

ORIGINAL CRIMINALIST DECIDES DNA TESTING ON NEGATIVE ITEMS FOR POST-CONVICTION TESTING



SPECIAL AGENT DEAVER FALSIFIED REPORTS AND TESTIMONY

2004 MACROSCOPIC EXAM

Prior to post-conviction testing, no test for identification of human blood was performed

Item #3 (Your 31) - sealed brn p. bag cont. a pair of black boots from George Goode Jr.

- visual exam. - initially; nothing of interest noted

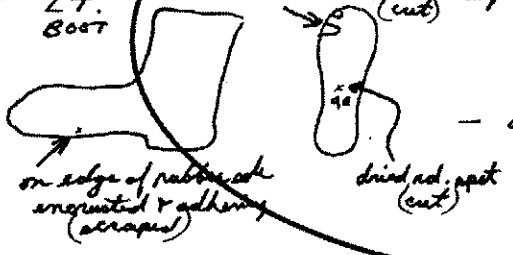
- stereo exam. - nothing found on rt. boot; lt. boot - found 3 areas of interest 5/3/04

- consulted Biscette, Budzynski re: spots √all agreed on spots

all 3 cuts/scrapes removed & placed in vial

returned over to S/A Biscette on 5/14/04

Lt. Boot



Item # 4 (Your 32B) - sealed brown p. bag cont. a pair of dark green coveralls (heavily soiled) from George Goode Jr.

- visual exam. - noted circled area w/ pen spots
- nothing else noted

see p. 3, 4 & 7 for measurements & descriptions

- stereo exam. - noted spots of interest & circled area. assigned letters

* cuts of A-E made on 5/11/04,

note: searched fabric around [illegible]

FAILURE TO DISCLOSE..

- 5/28/04 The DNA profile obtained from the cuttings from the coveralls is consistent with a mixture. The DNA profiles obtained from the standards submitted for the victims cannot be excluded as a contributor to the mixture. **Additional bands were present which cannot be accounted for by the standards submitted.** No population frequency data were generated for this item.

- The DNA profile obtained from the left boot matched the DNA profile obtained from the male victim.

- 6/16/04 The DNA profile obtained from the cutting from the coveralls is consistent with a mixture. The DNA profiles obtained from the standards submitted for the victims cannot be excluded as a contributor to the mixture. No population frequency data were generated for this item.

- The DNA profile obtained from the left boot matched the DNA profile obtained from the male victim.

DNA was a mixture and contamination was detected. The contamination was not disclosed in the final report – only available by examination of case file

Table 7: The role of forensic science – by number and percent of cases [*]

Rank	Percent	Cases	Description
1	36%	83	Non-specific science failed to exclude the defendant
2	33%	76	Conviction was not supported by forensic evidence
3	17%	39	Forensic evidence was favorable to the defendant
4	15%	34	Forensic science malpractice
		232	

- Original case – question of involvement in a stabbing incident
- Issue – no blood on the defendant compared to other 3 individuals – was he directly involved or a witness?
- Issue – compounded by post-conviction testing with DNA
- DNA – source of the sample; not useful for reconstruction after extensive contamination in courthouse storage
- Issue – compounded by fraud and bias in North Carolina system

Misapplication of circumstantial information during legal and judicial interpretation of scientific findings -

good example – contextual contamination

NORTH CAROLINA VS. SAMUEL MCCULLUM – 2007

BIOLOGICAL EVIDENCE

- DNA report identified a semen match from defendant to the victim
- Deceased victim led a high risk lifestyle – prostitute, drug informant, transient residence, in contact with a lot of different individuals
- Investigative information and semen information identified Mr. Samuel McCullum and he was scheduled for trial – homicide and sexual assault charges in 2006
- After review of all evidence logs and context, charges were dropped

Physical Evidence

	Description	Where Found/Found By
(1)	DNA from Vaginal Swabs	Victim
(2)	Hair	Victim's hands
(3)	Pubic Hair	Victim's chin
(4)		

TYPE EXAMINATION REQUESTED:

Hair analysis.

RESULTS OF EXAMINATION:

Examination of Items # 1-4 (tapings from victim's head and neck) and #17(trace evidence from right hand of victim) each revealed the presence of one Negroid body hair.

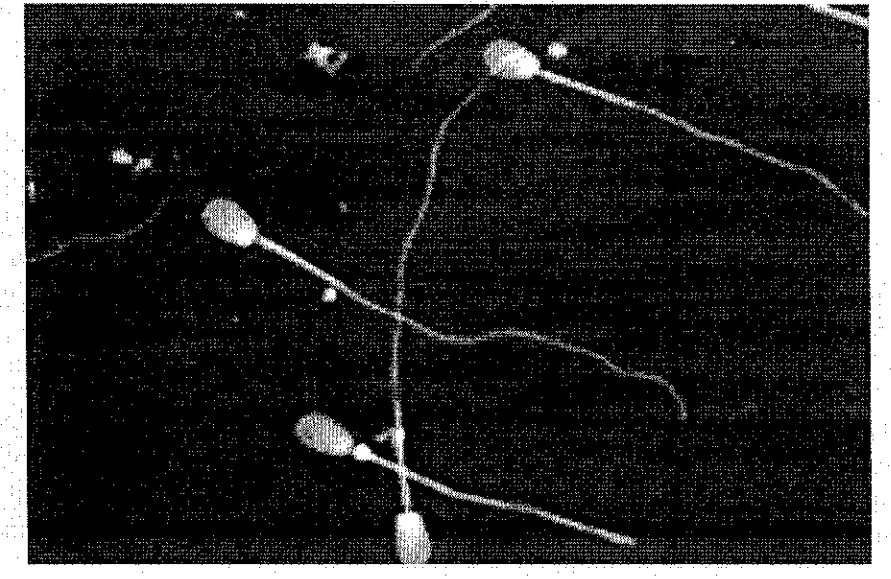
Examination of Item #17 (trace evidence from right hand of victim) also revealed the presence of one Caucasian head hair that was not consistent with the victim's head hair standard (Item #11).

Examination of the remaining hairs in Item #17, and Items #9, #18 and #19 did not reveal a transfer of hair from the suspects.

Items # 1-1, 1-2, 1-3, 1-5, 1-6. 1-7, 1-8, 6, 15 and 16 were not examined.

VALUE OF HAIR EVIDENCE

PRIMARY AND SECONDARY TRANSFER



Detection – differences from intimate swabs vs. non-intimate swabs

ISSUE – TIMING OF SEMEN DEPOSIT

72 HOUR WINDOW FOR INTIMATE SWABS

J Forensic Sci, Sept. 2002, Vol. 47, No. 5
Paper ID JFS2001398_475
Available online at: www.astm.org

Max M. Houck,[1] *M.A. and Bruce Budowle,*[2] *Ph.D.*

Correlation of Microscopic and Mitochondrial DNA Hair Comparisons

ABSTRACT: Expert opinions regarding the microscopic comparison of human hairs have been accepted routinely in courts for decades. However, with the advent of mitochondrial DNA (mtDNA) sequencing, an assessment can be made of the association by microscopic hair comparisons in casework between a questioned hair and reference hairs from an individual. While each method can be used separately, the two analytical methods can be complementary and together can provide additional information regarding source association. Human hairs submitted to the FBI Laboratory for analysis between 1996 and 2000 were reviewed. Of 170 hair examinations, there were 80 microscopic associations; of these, only nine were excluded by mtDNA. Importantly, 66 hairs that were considered either unsuitable for microscopic examinations or yielded inconclusive microscopic associations provided mtDNA results. Only six hairs did not provide sufficient mtDNA, and only three yielded inconclusive results. Consistency was observed in exculpatory results with the two procedures. This study demonstrates the utility of microscopic hair examinations and the strength of combining microscopic analysis with mtDNA sequencing.

KEYWORDS: forensic science, microscopic hair comparisons, mitochondrial DNA, significance

HAIR IN VICTIM'S CLENCHED HAND

CLOSER TO TIME OF DEATH

Table 7: The role of forensic science – by number and percent of cases [36]

Rank	Percent	Cases	Description
1	36%	83	Non-specific science failed to exclude the defendant
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4	15%	34	Forensic science malpractice
		232	

DNA – timing of deposit

DNA – circumstances of deposit

To minimize the effect of contextual contamination, there is a need to look at the biological and case evidence in totality

MCCULLUM CASE – IDENTIFIED IN REVIEW

CONTEXTUAL CONTAMINATION

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THANK YOU

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THANK YOU