Silent Witness - Volume 10, Number 3, 2006

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Low Copy Number DNA: Reality vs. Jury Expectations

On March 23, 2007, Jauquin Jaron Byrd was convicted of a brutal murder, in part, as a result of expert testimony relating to "low copy number" or "touch DNA" evidence processed from several items used to kill the victim. In trial, a forensic scientist from the Pennsylvania State Police's DNA laboratory testified that there was better than a 99 percent chance that touch DNA recovered from biological evidence found on the handle of a hammer and pair of scissors found at the murder scene was a mixed sample matching DNA from both Byrd and the victim1.

Touch DNA, also referred to as low copy number DNA (LCN) or low-level DNA2, results when an individual comes into contact with or touches an object, leaving small amounts of biological material on the object's surface. Increasingly in the UK and other countries, touch DNA is being processed to assist investigators in criminal cases3. In this country, the State of Washington and several others are currently crafting legislation which will require DNA testing be performed on all weapons recovered in connection with felony crime4 within their jurisdictions. This legislative trend, together with advances in technologies designed to obtain touch DNA for investigative purposes should make the task of linking individuals to a crime weapon easier in the future. Nonetheless, and especially in the aftermath of Byrd, prosecutors should be aware of the limitations and challenges to this form of DNA evidence.

Low Copy Number DNA

With the advent of CSI forensic entertainment programs, juries increasingly expect that law enforcement officers are able to recover viable forensic evidence from any crime scene surface, and that every forensic laboratory is equipped with the resources and technology to process and analyze this evidence within a short period of time. Often prosecutors must resort to calling a "negative evidence" expert witness to explain, for example, why fingerprints were not collected from a crime gun5. Ironically, while traditional forensic wisdom holds it is unlikely a usable fingerprint will be recovered from a firearm, the same surfaces which impede investigators' ability to obtain a usable print may serve as an excellent repository for body oil containing a sufficient amount of the user's skin cells for either LCN or standard analysis.

LCN DNA typing has been defined as "the analysis of any results below the stochastic threshold for normal interpretation,"6 using samples of microscopic amounts of DNA for analysis, often as little as 100-200 pg input DNA7. Between 1985 and 1995, using increasingly sophisticated technologies, analysts went from requiring quarter-size evidence samples to processing barely visible samples containing as few as 50-100 cells8. The scientific forensic community in the UK has processed as few as 15-20 cells in an evidence sample, using the results successfully for investigative purposes9.

Limitations and Challenges

Despite the fact LCN processing can yield potential investigative information there are many caveats associated with it including:

- **Amplification:** The process for obtaining LCN DNA requires an

analyst increase PCR-amplification from 28 to 34 cycles. Traditionally, DNA processing technology has been thought to work most efficiently when amplification is limited to 28-30 cycles. In some instances fingerprints have been analyzed at 28-40 cycles and rootless hair shafts at 35-43 cycles.10

- **Threshold:** Since results fall below the normal PCR interpretation threshold, at this time, there is no standard stochastic threshold accepted between laboratories to use in the evaluation of the LCN processing results.

- **Contamination:** A common consequence of increased PCR-amplification is that analysts see background DNA contamination resulting from DNA left by an amalgamation of the various individuals who handled the object and not exclusively from those individuals involved with the criminal act under investigated.

- **Alleles drop-out:** Allele drop-out may occur if one allele of a heterozygote locus is preferentially amplified in the increased PCR-amplification process.11

- **Allele drop-in:** Additionally, LCN typing is susceptible to allele drop-in (sometimes called stutter false alleles12) or the appearance of artificial STR profiles. Typically allele drop-in is not reproducible and thus by repeating the process multiple times without obtaining identical results, the analyst can identify the problem as allele drop-in.

- **DNA Mixture:** The problems with LCN DNA typing are exacerbated when the evidence is a mixed same-gender sample as opposed to a mixture of male and female DNA. An analyst may have difficulty in determining whether a true mixture exists in the evidence sample and separate out its contributors.13

- **Artifacts:** Other caveats associated with LCN typing include potential bleed through, instrument spikes, increased potential for PCR artifacts and stutter14.

Since DNA analysis does not shed any light on the timeframe in which a biological sample was deposited, most LCN typing, unlike other DNA typing, cannot be used for exculpatory purposes15.

With all of these caveats, what is the potential value of LCN, now or in the future to assist criminal investigations? In reality, crime scene evidence sometimes contains insufficient DNA to render a full or partial DNA profile using standard forensic typing procedures. As a last resort screening tool for investigative purposes analysts may consider evaluating the evidence for LCN typing but only after weighing a number of issues including how critical this evidence might be in relation to all other available evidence, the various problems associated with this typing process and available resources.

FUTURE APPLICATIONS

At the recent American Academy of Forensic Scientists annual meeting in San Antonio, Texas, several forensic scientists discussed emerging methodologies relating to LCN. One discussion focused on using a simplified LCN DNA analysis using a standard 28 cycle amplification process followed by post-PCR purification. In test studies with dermal ridge fingerprint, these scientists were able to obtain genetic profiles using the standard amplification rather than increased cycles, followed by a post-PCR purification process. In contrast the scientists found using a standard 28 cycle amplification process without the post-PCR purification step failed to yield any genetic profiles from similar fingerprints16. Studies using more traditional methods of obtaining DNA from fingerprints and published in 2003 indicated that in a significant number of 374 fingerprints tested, little or no DNA was detected17. Hopefully, with further development and validation, the standard 20 cycle amplification followed by a post-PCR purification process will be able to assist the criminal justice system in the future.

Additionally, since 2000, Bode Technology Group of Springfield, Virginia has been doing research on isolating mitrochondrial DNA (mtDNA) from fingerprints. Bode has successfully developed a method to obtain mtDNA from processed fingerprints on both non-porous and porous surfaces as part

of an effort prompted by the Technical Support Working Group, (TSWG) a national forensic community that identifies, prioritizes and coordinates research and development programs relating to DNA. In test cases, LCN DNA has been obtained from fingerprints lifted from a number of types of abrasive surfaces, for example, rope, knife handles, baseball bats, items often associated with a crime scene.

In 2002 Bode began research involving nuclear DNA from processed latent fingerprints. This too is in the validation and implementation stage, and hopefully will be available for court and case work in 1-2 years. The status of both approaches can be tracked at www.bodetech.com/research/humandna_str.html.

Conclusion

Despite its use in the UK and elsewhere, LCN DNA's application in the US is exclusively used as a last resort screening tool in the investigation stage of a criminal case to narrow the universe of suspects and/or eliminate the wrongfully accused. Ideally with time the technology to obtain LCN DNA will become more discriminating and its use as an investigation tool will help bring justice in those cases where more traditional profiling techniques have been exhausted.

Endnotes

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