The research and development programs of the National Institute of Justice: providing long-term solutions to everyday challenges

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In recent years, scientific and technological research has advanced at a pace never before seen. But forensic scientists know that in order to take advantage of technological innovations, there must be a focused effort to harness these innovations and adapt them for use in the crime laboratory. The forensic science research and development programs of the Office of Justice Programs' National Institute of Justice (NIJ) are doing just that. As part of NIJ's ongoing efforts to bring cutting edge technologies to the forensic DNA community, NIJ continues to support novel DNA research focused on a variety of topics designed to provide long-term solutions to everyday challenges.

The National Institute of Justice is the research, development, and evaluation agency of the U.S. Department of Justice. The goal of NIJ's Forensic DNA Research and Development Program is to harness the tremendous growth in the broader scientific fields (such as molecular biology, genetics, and biotechnology) and direct it toward the development of highly discriminating, reliable, cost-effective, and rapid forensic DNA testing methods. Projects under this program focus on tools to increase the success rate of the analysis of biological evidence that is degraded, damaged, limited in quantity, or otherwise compromised; tools for better separation of the male and female fractions of sexual assault evidence; identification and characterization of genetic markers that can reveal additional information about the source of the DNA evidence; and development of miniaturized, high-throughput DNA testing devices.

NIJ's Technology Working Groups (TWGs) support the Research, Development, Test and Evaluation (RDT&E) process within NIJ's Office of Science and Technology. The DNA Forensics TWG meets twice each year (Fall and Spring) and includes practitioners from State, local, and Federal laboratories as well as private industry. The TWG is tasked with identifying technology needs and defining operational requirements for DNA crime laboratories. These needs and requirements help to validate NIJ's planned and ongoing research and development activities, as well as help ensure that future technologies developed under NIJ's Forensic DNA Research and Development Program continue to meet practitioner-driven needs.

The Forensic DNA Research and Development Program has resulted in several deliverables that have advanced the field and will be of value to the practitioner community. Examples include the following:

Mini-STRs:
NIJ has developed an alternative approach for the analysis of the 13 Short Tandem Repeat (STR) markers currently used for analyzing biological evidence. Research performed by Ohio University/ Florida International University and the National Institute of Standards and Technology (NIST) resulted in the development of "mini-STRs". Mini-STRs allow STR testing to be performed on smaller fragments of DNA and are especially applicable to degraded DNA evidence, such as that recovered following mass disasters or in missing persons investigations.

DNA Quantitation:
NIJ has improved the tools available for quantitation of human DNA. Researchers from the Vermont Department of Public Safety and California Department of Justice have developed several human DNA quantitation assays, including assays that simultaneously quantitate nuclear, mitochondrial, and Y chromosome DNA, as well as an assay that combines DNA quantitation with an assessment of the level of DNA degradation.

DNA microdevices:
A field-portable STR identification instrument, based on NIJ-funded research performed by MIT and NIST, has been commercialized by Network Biosystems. This instrument can function both at the crime scene and

the forensic laboratory. A DNA microdevice developed by University of California Berkeley is currently undergoing testing and evaluation by crime laboratory practitioners.

Sperm detection and separation:
NIJ has developed novel tools which will expedite the detection and separation of sperm cells in sexual assault evidence. These tools include "SpermPaints" (University of Virginia), which use fluorescent tags to "light up" sperm on microscope slides, as well as laser microdissection (Rosalind Franklin University), which is used to isolate and separate sperm cells.

Autosomal Single Nucleotide Polymorphisms:
NIJ has developed a battery of candidate autosomal single nucleotide polymorphisms (SNPs) for a universal individual identification panel. A panel of 40 SNPs was developed by Yale University that can generate match probabilities of less than 10^{-16}.

Evidence Screening:
NIJ has developed a fast, inexpensive method to quickly screen crime scene samples and expedite the analysis of probative samples. While it does not yield individual-specific DNA profiles, a method was developed by the Vermont Department of Public Safety that can quickly differentiate between approximately 95-99% of samples from different individuals (such as victims and perpetrators). The assay is fast, less expensive than STR analysis, and uses a quantitative PCR instrument, which is now found in most forensic and molecular biology laboratories.

Mitochondrial DNA:
NIJ has advanced the tools available for examining mitochondrial DNA. Mitochondrial DNA analysis is primarily used when the biological evidence is severely degraded or limited in quantity. This includes:

- A linear array assay developed by Roche was successfully used on skeletal remains recovered from mass graves in Croatia which could not be analyzed with traditional nuclear DNA markers. This assay is being expanded to include additional polymorphisms to make a single mtDNA control region/ coding region assay.
- The Armed Forces DNA Identification Laboratory (AFDIL) performed population studies to identify coding region SNPs that can increase the discriminatory power of mtDNA testing. This information has been used to assist in the identification of casualties from military conflicts.
- A denaturing high performance liquid chromatography (dHPLC) method to separate mtDNA mixtures has been developed by the University of Denver. Evaluation, developmental validation, and protocols are being finalized.

In addition to research and development, NIJ has implemented several mechanisms to assist in the transition of forensic research deliverables into practice. These mechanisms include:

- Publications and products (see the Research page of www.dna.gov)

- Testing, evaluation, and validation of research deliverables by crime laboratory practitioners.

- Presentations by researchers at the DNA track (formerly the DNA Grantees Workshop) of the annual NIJ Conference and at the DNA Forensics TWG meetings.

- Technology Transition Workshops. During 2006/ 2007, the following workshops were facilitated by NIJ in conjunction with the National Forensic Science Technology Center:
    - Quantitative PCR
    - Mitochondrial DNA
    - Laser Microdissection
    - LC/MS/MS for toxicology
    - Capillary Electrophoresis for Clandestine Methamphetamine Lab Evidence
    - Questioned Document Analysis

As the Forensic DNA Research and Development Program moves forward, the input and perspective of the DNA practitioner community will continue to play a vital role in helping to focus and strengthen NIJ's research deliverables.