# Applied Research to Support the Forensic Sciences: 2012 Awards by the National Institute of Justice

In 2012, NIJ awarded more than $9.5 million for applied research to increase the strength of the forensic science disciplines. This work is intended to: 1) increase the knowledge or understanding necessary to guide forensic science policy and practice, and 2) result in the production of useful materials, devices, systems or methods that have the potential for forensic application. The mission is to develop highly discriminating, accurate, reliable, cost-effective and rapid methods for identifying, analyzing and interpreting physical evidence for criminal justice purposes.

Here are brief descriptions of the 24 applied research awards made in 2012.

## Impression Evidence: Toolmarks

**Recipient:** Ames Laboratory, Iowa State University

**The criminal justice problem:** The hardware systems currently being used to forensically analyze toolmarks must be improved.

**The research:** Through this interagency agreement, scientists at Ames Laboratory will develop a prototype system to enhance the National Integrated Ballistic Information Network. This applied research will integrate software developed by Ames Laboratory/Iowa State University (AL/ISU) into the operating parameters of a profilometer. A software package called "Mantis" (Mark and Tool Inspection Suite) is under development; it will incorporate algorithms developed at AL/ISU for striated toolmark analysis. Forensic examiners in the field will conduct a series of tests to determine the viability of the prototype. The goal of this project is to develop a system that: 1) compares all types of toolmarked surfaces; 2) is portable so that it can be taken directly to a crime scene; 3) provides objective statistical evaluation of data files; 4) describes factors that existed when the toolmark was made; 5) provides an open-source platform that other researchers can write algorithms for and test; and 6) is affordable to crime laboratories.

## Impression Evidence: Firearms

**Recipient:** Cadre Research Labs, LLC

**The criminal justice problem:** There is a need in the field for improved imaging technology and matching algorithms for firearm and toolmark identification.

**The research:** Scientists will create several prototype imaging and comparison systems and a moderate-scale cartridge case comparison study, which will be evaluated by members of the forensic firearm community. The project combines the recently developed GelSight high-resolution surface topography imaging system with state-of-the-art algorithms for matching image features. The goal is that the system will allow for the computation of a match's statistical significance. In the future, the framework may be able to be used for other toolmark comparisons, such as bullets and marks of forced entry.

## DNA: Familial Searching

**Recipient:** City and County of Denver

**The criminal justice problem:** Familial DNA searching can be a valuable investigative tool in criminal investigations through the identification of possible siblings and parent-child relatives of persons who are in the Combined DNA Index System (CODIS) database. Although five states (Colorado, California, Wyoming, Virginia and Texas) have, to date, implemented familial search programs, there are limitations to current standalone systems. For example, the Familial Search Program system developed in Denver lacks both the ability to reach a larger number of users and the computational power to handle larger data sets and searches.

**The research:** Through this grant, the Denver Crime Laboratory will partner with the Denver DA and DRC Computer Corporation to develop a Web-based familial search system that could be useful to other jurisdictions. The goal is to have a system that can compare millions of DNA profiles, allowing familial or exact CODIS matches to be derived in seconds over an encrypted and secure data environment. The project will determine the utility of using expected match ratio and expected kinship ratio calculations to detect true-positive results by applying the analysis to existing known familial matches from Denver DNA data. The tool will be designed to narrow familial searches to assist law enforcement, particularly in cases in which investigative leads have been exhausted.

## Forensic Biology: Body Fluid Analysis

**Recipient:** City of New York, Office of Chief Medical Examiner

**The criminal justice problem:** Body fluid identification plays a vital role in forensic investigations, particularly in sexual assaults. Unfortunately, current methods used for body fluid detection are a diverse mixture of techniques that vary dramatically in sensitivity, reproducibility, speed, cost and above all specificity. Most are not confirmatory, and there are body fluids (such as menstrual blood and vaginal fluid) for which no routine tests are currently available.

**The research:** Scientists will build on previously funded projects and continue work toward developing a single confirmatory method able to simultaneously detect all body fluids accurately, reproducibly, rapidly, with high sensitivity and at low cost. In this phase of the project, researchers will capitalize on recent advances in protein chromatography (combinatorial peptide-ligand chromatography) and microwave technology (microwave-assisted trypsin digestion and microwave-assisted deglycosylation) and evaluate these new technologies for integration into existing assays. Researchers will also evaluate methods for the simultaneous extraction of protein and DNA from samples to conserve sample use. Additionally, researchers will evaluate the stability of menstrual blood and vaginal fluid markers over time and assess the potential use of recently published vaginal fluid flora as additional markers for use in their vaginal fluid assay. Researchers will evaluate the ability of chemical properties of body fluid marker proteins to bind to and be enriched by a novel protein chromatography matrix. The ultimate goal is to integrate new chemistries and instrumentation into a single assay for the detection of complex (menstrual blood and vaginal fluid) and mixed body fluids. If successful, this assay system has the potential to be faster, more sensitive and less expensive than current methods.

## DNA: Physical Separation of Cells

**Recipient:** City of New York, Office of Chief Medical Examiner

**The criminal justice problem:** Technologies are needed to more effectively test evidence — from homicides, sexual assaults, felony assaults and property crimes — that contains relatively small amounts of DNA, particularly items that have been touched, including clothing with no apparent biological staining. Because evidence is often touched by multiple people (not just a single perpetrator, but perhaps multiple perpetrators and the victim), it can contain DNA from multiple individuals — and deconvoluting the data produced from DNA analysis of these mixtures can be difficult. However, microscopy and micromanipulation techniques may allow the separation of microscopically visible mixture contributions before they inadvertently become pooled in a DNA extraction. For example, individual contributors can be determined by cell type; sperm and epithelial cells may be distinguished by morphology; skin flakes may be grouped by the placement of individual contributors on the object; and specialized staining techniques can allow visual discrimination of male and female cells of the same morphology.

**The research:** This grant will help crime laboratories more effectively process DNA from touched and trace biological materials. The goal is to provide situational and substrate-specific (such as door handles and items of clothing) recommendations for using three micromanipulation techniques: manual microdissection with and without the use of adhesive microglobes, laser capture microdissection, and robotically assisted microdissection. The project will also develop a highly efficient method of direct polymerase chain reaction (PCR), which will be universal to obtaining the short tandem repeat (STR) profiles of the individual contributors to these substrates. The Direct PCR method will streamline processes, reduce cost and minimize DNA loss. The resulting STR profiles will be compared with paired identical substrates processed with High Sensitivity DNA analysis methods currently used by the operational laboratory. The results of this comparative evaluation will aid other labs seeking to more effectively process DNA from touched and trace biological materials.

## Forensic Biology: Body Fluid Analysis

**Recipient:** Colorado Seminary (which owns the University of Denver)

**The criminal justice problem:** Although DNA profiling makes it possible to individualize biological stains, identification of the stain itself can be challenging. For example, if a genetic profile from a swab of a male suspect's finger is consistent with that of a female victim of an alleged sexual assault, more than one interpretation is possible: Did the male sexually assault the victim by digitally penetrating her, or did the female lick the suspect's finger, leaving her DNA? The ability to reliably determine whether the suspect's finger contains traces of saliva and/or vaginal secretions would help investigators better evaluate these types of alternate interpretations.

**The research:** Through this award, scientists under the direction of Dr. Phil Danielson will build on previously funded projects and continue work to improve the accuracy and sensitivity of forensic serological testing by focusing on the use of protein biomarkers and mass spectrometry for the confirmatory identification of biological stains. The goal of this phase of the project is to develop and test a faster, more accurate and more sensitive multiplex assay for the simultaneous identification of six stains (saliva, semen, peripheral blood, menstrual blood, urine and vaginal fluid, for which there currently are no accurate tests). A successful project will result in a completed developmental validation study, protocols and interpretation guidelines. A multiplex design should eliminate the need to perform separate tests on an unknown stain.

## Patterned Injuries in Medicolegal Death Investigations

**Recipient:** East Carolina University

**The criminal justice problem:** The evaluation of patterned injuries of the skin can provide forensic pathologists with important information about the nature of an object used to inflict trauma on a victim, although the interpretation of pattern injuries of the skin can be problematic.

**The research:** Through this cooperative agreement, scientists will address the basic issue of the ability of forensic pathologists to interpret patterned injuries through various tests of generally established patterns. Furthermore, the researchers will examine the use of image processing in the interpretation of patterned injuries and will provide an objective measure of the usefulness of these methods.

## DNA: Low-Template DNA Analysis

**Recipient:** General Electric Company

**The criminal justice problem:** DNA profiling by short tandem repeat (STR) analysis is a powerful tool for obtaining genetic information from biological material, which can help link persons, places and objects. Although current STR analysis works very well with relatively abundant and fresh or well-preserved samples, it is often difficult to obtain complete genetic profiles from low-template samples that may contain only a few cells of genetic material. The profiles obtained from low-template samples can suffer a complete loss of genetic loci and the dropout of individual alleles; they also can suffer from increased stutter peaks, allelic imbalance and allele drop-in that results from stochastic effects that occur during the polymerase chain reaction. Analysis is especially difficult for low-template samples that have been exposed to environmental factors that affect DNA integrity.

**The research:** With this award, researchers under the direction of Dr. John Nelson will work to develop improved tools for examining limited or damaged genetic evidence. Specifically, they will adapt two separate, highly sensitive methods for the treatment of low-template samples that would pre-amplify DNA from a few copies to an amount sufficient for quantification and robust profiling in addition to archiving by:

- Improving whole-genome amplification, using the technique of multiple displacement synthesis by Phi29 polymerase.
- Adapting a novel locus-specific isothermal reaction method to pre-amplify only the desired STR loci from low-template DNA samples.

This work will be combined with previous NIJ-funded research developing integrated methods to repair some of the DNA template lesions and fragmentation caused by environmental exposure. If successful, the project is expected to yield optimized protocols and recommendations for sample-specific use of the technologies.

## Trace Evidence: Residue in Fingerprints

**Recipient:** George Mason University

**The criminal justice problem:** Detailed fingerprint image analysis is necessary for positive suspect identification. In many cases, inconclusive partial and/or smeared prints limit the value of the print data obtained. Substantially more information can be obtained from latent prints, which may further identify an individual's age or gender, indicate discerning habits or activities (tobacco, pharmaceutical

or drug use), establish a time frame for when the fingerprint was deposited, and identify environmental exposure to drug or explosive residue or precursors.

**The research:** Through this award, researchers — working with scientists from BAE Systems Inc. — will evaluate a way to extract and analyze trace chemicals from a latent fingerprint. Dusted and lifted latent prints will be collected from approximately 200 individuals, along with questionnaires describing various biometric (age and gender, for example) and other pertinent information, such as whether they smoke or use prescription drugs. Then, using a novel fingerprint powder that adsorbs chemicals, they will employ thermal (hard) and supercritical carbon dioxide (soft) techniques that are amenable to current forensic methods and maintain the latent print image. The chemical analytes extracted from the latent prints will be compared to an initial database that links chemicals in the fingerprints to biometric and other information. Finally, the data will be compared to the questionnaire answered by each individual to demonstrate a link between certain chemicals and biometric or other information. The researchers also will lace some latent prints with trace amounts of drug and explosive precursors to demonstrate that these types of chemicals can be collected and analyzed.

**Trace Evidence: Fiber Analysis**

**Recipient:** Microtrace LLC

**The criminal justice problem:** Currently, forensic fiber dye analysis is performed by empirical comparison methods that are not supported by chemical identification of the dyestuffs present on the fibers. In addition, no database of analyses using infrared, Raman or solution spectrophotometry exists.

**The research:** Through this award, researchers will create a comprehensive guide for identifying dyes in fibers. They will use the simple and inexpensive technique of thin-layer chromatography to separate at least 300 commercially important dyestuffs, then use microchemical techniques to extract the dyes from the separated spots and to allow the crystalline residue of the extract to be analyzed by micro-FTIR spectroscopy and solution spectrophotometry by UV-vis microspectrophotometry (MSP). To encourage adaptation by laboratories, the methods and validation will be provided in a format that conforms to International Organization for Standardization 17025 guidelines, a standard used by laboratories as a requisite for accreditation and as part of the quality system with the goal of consistently producing accurate and valid results. The project will also create the most extensive dye database — with FTIR, MSP and SERS data from 300 dyes identified by chemical name — ever created for forensic purposes.

**Trace Evidence: Fiber Analysis**

**Recipient:** Microtrace LLC

**The criminal justice problem:** Despite the fact that microspectrophotometry (MSP) analysis is one of the most established instrumental methods used in trace evidence comparisons — and it is used by nearly every laboratory that conducts trace evidence analysis — there are unaddressed topics that impact collection and interpretation of MSP data, particularly relating to spectral quality, spectral discrimination and the efficacy of ancillary methods.

**The research:** With this award, Microtrace scientists will create a guide to methods and interpretation in MSP analysis. With respect to spectral quality, for example, they will establish procedures to help analysts better understand:

- The impact of edge contrast due to differences in refractive index of fiber and mounting medium.
- The impact of delustrants and cross-section on reproducibility.
- Treatment of heavily, lightly and heterogeneously dyed fibers.
- Sample alteration from illumination-induced bleaching.

The goal is to formalize match criteria that is used to discriminate fibers. Resulting procedures and validation studies will be suitable for integration into ISO 17025-compliant procedures.

### Forensic Anthropology / Medicolegal Death Investigations

**Recipient:** North Carolina State University

**The criminal justice problem:** There were 1,460 cases of fatalities due to child maltreatment in the U.S. in 2005, according to the U.S. Department of Health and Human Services. These cases are difficult to investigate and resolve because there has been little scientifically based research — and due to the relatively small size of the victim, concealment of the body is common, meaning it may not be found before soft tissue decay and skeletonization. To date, a post-mortem interval estimation model does not exist for juvenile remains.

**The research:** Through this grant, North Carolina State University researchers will study many of the unknowns regarding body decomposition, specifically of children. The goal is to develop regionally specific bone weathering standards that could help provide more accurate post-mortem interval (PMI) estimates and thereby improve the solvability of unidentified human remains cases, particularly in juvenile homicides. Using immature pigs, the researchers will collect seasonal data over a two-year period to assess bone mineral density loss during the decay process and perform histological evaluation of diagenesis that results from the post-mortem environment. This is expected to assist in the estimation of PMI for juvenile remains.

### Trace Evidence: Paint Analysis

**Recipient:** Oklahoma State University

**The criminal justice problem:** The small size of automotive paint fragments that might typically be found at a crime scene make it difficult to accurately compare them with manufacturers' paint color standards or to obtain chemical information about the clear coat.

**The research:** Through this grant, researchers at Oklahoma State University will develop new techniques for pattern-recognition-assisted infrared (IR) library searching of the Paint Data Query (PDQ) automotive paint database developed with previous NIJ funding to determine the make, model and year of an automobile from an unknown paint sample recovered at a crime scene. The researchers will develop search pre-filters and library-searching algorithms for the PDQ database that can extract investigative information from clear coat and primer layer paint smears. Combining chemical information obtained from the Fourier Transform IR spectra of the two primer layers and from the clear coat layer should make it possible to rapidly and accurately identify the make and model and specify certain years of manufacture of an automobile from its paint system alone. In addition, information from pattern-recognition searches should improve the general discriminatory power of automotive paint comparisons and help analysts communicate the significance of this

evidence in court. Finally, the project will develop a "correction algorithm" to convert transmission infrared spectra in the PDQ library into attenuated total reflectance (ATR). This will allow the PDQ database to be searched using ATR spectra such as those currently generated by many forensic laboratories.

### Trace Evidence: Fiber Analysis

**Recipient:** Stoney Forensic Inc.

**The criminal justice problem:** Currently, the probative value of carpet fibers is limited because, as mass-produced commodities, identification is limited to class associations. However, very small particles (VSP) — which accumulate post-manufacture during the carpet's use — adhere to the surfaces of individual carpet fibers and can link these fibers to their source carpet.

**The research:** With this grant, scientists from Stoney Forensic will test new methods of carpet-fiber transfer and crime-scene sampling. The goals are to:

- Refine the process for exploiting VSP to associate residential carpet fibers with their source carpet.
- Apply this process in realistic casework conditions.
- Deliver working prototype methods for collection, analysis and interpretation of carpet fiber evidence.

Practitioners will use a simple, efficient kit to collect samples from 100 crime scenes in eight to 12 jurisdictions across the U.S. Using previously developed protocols for VSP recovery — along with existing methods for computer-assisted scanning electron microscopy analysis — the 200 samples (100 mated pairs) will be analyzed. This will allow improved VSP target particle type classification criteria to be established based on analysis of forensic performance characteristics. Using between-carpet data and existing within-carpet data, target particle types will be defined using unsupervised clustering. This will result in a set of compositional variables to describe VSP profiles. This new approach — which will be ready for validation processes within crime laboratory settings and for the next stage of improvements based on operational experience — is expected to increase the probative value (and provide a quantifiable measure of this value) of carpet fibers. It could also lay the groundwork for analysis of other types of trace evidence.

### Crime Scene Imaging

**Recipient:** Teledyne Scientific & Imaging LLC

**The criminal justice problem:** Crime scene investigators are tasked with detecting and collecting physical evidence present at the scene, including body fluids, hairs, fibers and latent prints. These are often difficult to distinguish from the background and may present a formidable challenge to detect and identify. Different materials comprising crime scene evidence of interest may require a range of techniques for contrast enhancement; no single, integrated device incorporates even a few of these techniques. The forensic crime scene community needs a "one-stop shop" camera to detect and document forensic analytes of interest at the scene.

**The research:** Through this grant, Teledyne Scientific & Imaging will build upon previous research and test a portable, user-friendly brassboard multispectral forensic survey camera — and demonstrate it using simulated crime-scene targets. The camera is expected to improve flexibility, speed and efficiency in surveying a crime scene during the day or night, in indoor or outdoor conditions. It will

use multispectral and fluorescence imaging with pulsed illumination and user-selectable polarization to detect and identify fingerprints, body fluids, stains and other residues at the crime scene.

### Trace Evidence: Explosives Detection

**Recipient:** Florida International University

**The criminal justice problem:** Improvised or homemade explosives, which were once limited to war zones, have now become a concern for law enforcement and other first responders in the United States. Fast and accurate identification of the explosive compound used is of the utmost importance in these situations. Existing detection methods use large, expensive pieces of equipment that are largely not portable and that are not suitable for presumptive screening by non-scientists.

**The research:** With this grant, researchers at Florida International University will use paper microfluidics — a transformational technology in which designs are printed in wax-based ink on chromatography paper — to develop and validate a device capable of providing fast and sensitive colorimetric detection of the constituents of improvised or homemade explosives in pre- or post-blast settings. The device will be small (no larger than a package of cigarette papers), easily stored for long-term performance, able to perform five or more simultaneous analyses and — because of the low cost of the basic components (chromatography paper, wax and small quantities of reagents) — very inexpensive.

### DNA: Sexual Assault

**Recipient:** The George Washington University

**The criminal justice problem:** Sexual assault evidence makes up a large part of the backlog in many crime laboratories, and in many laboratories, it is common practice to process sexual assault evidence for the identification of seminal fluid. One current practice for presumptively identifying seminal fluid uses an alternate light source as an enhancement tool followed by testing for seminal acid phosphatase. If the result of this test is positive, some laboratories then use commercially available immunochromatography kits to test for prostate specific antigen (PSA or p30). However, because PSA has been identified at very low levels in other body fluids, not all forensic analysts consider a positive PSA test result to be confirmatory for seminal fluid. The only undisputable confirmatory test for the presence of semen is the microscopic observation of spermatozoa, which can be extremely time-consuming. Particularly in samples with low levels or no spermatozoa, analysts may spend hours searching a slide. Although automated sperm-searcher systems decrease the time spent on a single sample, they can process only one sample at a time. Also, fluorescent microscopes and automated sperm-searching technology are costly. Therefore, a faster, more cost-effective method for identifying spermatozoa — amenable to automation — is needed.

**The research:** With this grant, researchers from the George Washington University, under the direction of Dr. Daniele Podini, will develop and optimize a proximity ligation real-time PCR (PLiRT-PCR) assay that targets sperm-specific proteins. The detection of these proteins will serve as a confirmatory test for the presence of spermatozoa and allow faster and more efficient processing of sexual assault evidence. The assay combines the specificity of an immunological reaction with the sensitivity of PCR, using the RT-PCR technology that is already commonly used in crime labs.

## Forensic Pathology

**Recipient:** University of Michigan

**The criminal justice problem:** Establishing whether a child's head injury is the result of a short fall or abuse is a fundamental problem in forensic investigations. Expert opinions regarding how a child's head injury occurred are often not based on scientific evidence and sometimes are in direct conflict with the evidence, which can result in wrongful legal action.

**The research:** With this grant, University of Michigan researchers will establish a new pediatric head finite element (FE) model to improve the assessment of head injuries in children from 0 to 3 years old. The model will require users to input basic information such as age, weight, height, head circumference, and/or head CT/MRI images to rapidly generate a subject-specific head FE model. If incident conditions are also defined — such as fall height, fall angle, and impact surface material and thickness — the model will be able to predict a range of skull/brain injury risks based on model-calculated results and provide a statistical assessment of whether the existing head injury is consistent with the stated injurious event.

This pediatric head-injury assessment tool is intended to provide useful, accurate and objective information for both clinicians and forensic investigators to aid in determining the cause of a pediatric head injury.

## DNA: Mixture Interpretation

**Recipient:** Boston University Medical Center

**The criminal justice problem:** DNA mixtures may be composed of a number of contributors, combined in any proportion. Currently, two methods of interpreting DNA analysis are used ("random man not excluded" and "likelihood ratio"), and laboratory personnel must validate and determine analysis parameters for each. The random man not excluded method is a binary scheme that assumes alleles are either absent or present. The likelihood ratio method assesses DNA evidence probabilistically to compare a prosecution hypothesis and a defense hypothesis. Both methods require assumptions to be made prior to analysis and may not be suitable for multicontributor, low-level samples. In addition, the signal obtained from biological evidence may be extremely complex, and the signal from the person-of-interest may not be distinguishable from baseline noise, polymerase chain reaction/instrument artifact and other contributors.

**The research:** With this award, researchers under the leadership of Dr. Catherine Grgicak at Boston University will develop a novel approach to interpreting data generated from complex and/or low-template DNA samples. The technique will focus primarily on distinguishing whether the known could be discerned from artifact, noise and other contributors. The researchers will use matched filter techniques from the digital communication field. This matched filter approach (unlike existing mixture interpretation schemes that attempt to infer genetic profiles directly) uses systematic comparisons of the crime scene profile to those from persons-of-interest to include or exclude individuals as potential contributors and provides statistical weight to that conclusion. Dr. Grgicak's team will also work with Dr. Desmund Lun from the Department of Computer Science at Rutgers University and Dr. Muriel Medard from the Department of Electrical Engineering and Computer Science at the Massachusetts Institute of Technology to develop DNA mixture interpretation algorithms and prototype software designed to apply statistical and computational techniques that can accurately assess complex, noisy samples involving many contributors.

## DNA: Next Generation Sequencing

**Recipient:** University of North Texas Health Science Center

**The criminal justice problem:** The Combined DNA Index System (CODIS) houses DNA profiles and is relied upon routinely for helping to develop meaningful investigative leads. These DNA databases continue to increase in size, and although the demands of generating, entering and maintaining DNA profiles in a national DNA database have fostered developments in automation and molecularly robust assays, new technologies are needed to continue to meet the increasing demands. Across the nation, the number of DNA reference samples from convicted felons, arrestees, detainees and missing persons continues to increase with no indication that the demand for DNA testing will subside. New technologies that can augment the current set of core loci for CODIS are also needed.

**The research:** With this award, researchers under the direction of Dr. Bruce Budowle will look at next generation sequencing (NGS) technologies on the Genetic Analyzer IIx and the Ion Torrent Personal Genome Machine platforms. NGS technologies have the potential to allow a large battery of markers to be analyzed simultaneously, far exceeding the current capacity of 15-21 short tandem repeats (STRs) in commercial kits. The researchers will examine whether all forensically relevant identified autosomal STRs (such as the 24 STR loci selected by the FBI and beyond) can be typed simultaneously with a set of Y-STRs and X-STRs, and human identity single-nucleotide polymorphisms (SNPs) (400-500 markers), in a single multiplex approach. Additionally, researchers will use NGS "barcoding" techniques to type many different reference samples simultaneously. The researchers will also convert mitochondrial DNA (mtDNA) sequencing to an NGS platform approach (mtDNA would initially have to be typed separately because of its sheer number of copies compared with nuclear DNA). The project will result in a complete evaluation of NGS technologies. The project has the potential to develop the capability to type reference samples for a large battery of autosomal, Y chromosome, and X chromosome STRs and human identity SNPs in a single multiplex analysis. The methodologies that the researchers will explore are intended to provide sufficiently robust data so that DNA profiles meet the criteria for uploading to CODIS.

## DNA: Kinship Analysis

**Recipient:** University of Utah

**The criminal justice problem:** The ability to identify individuals from traces of their DNA has proved invaluable in forensic identification of the remains of missing persons, victims of mass disasters, and both victims and suspects in criminal investigations. However, direct reference samples cannot always be obtained, and more tools and technologies are needed to detect distant relationships between people with high certainty. Identifying individuals by comparing DNA profiles from questioned biological samples to those of presumptive relatives assists in generating leads in criminal investigations and in mass disasters, including the identification of unknown human remains. Our current capabilities, however, are constrained by the need for multiple immediate relatives to achieve a high certainty of identification.

**The research:** With this award, researchers from the University of Utah's Department of Human Genetics under the direction of Dr. Lynn Jorde will perform work toward developing the ability to link DNA samples to distant relatives of the sample donor with high confidence, even when the DNA sample provides incomplete and error-ridden data. This project will employ a computational method (estimation of recent shared ancestry, "ERSA") that uses high-density single-nucleotide polymorphism (SNP) genotypes to link relatives as distant as third cousins with high confidence. The crucial advantage of high-density genotyping methods is the vast number of loci they interrogate. This

enables them to collect very large amounts of accurate information even with high per-locus failure rates that may be observed with forensic DNA samples. Dr. Jorde's team will collaborate with Dr. Thomas Parsons of the International Commission for Missing Persons to combine ERSA expertise with long-term forensic DNA experience in order to test and extend the performance of ERSA and other relationship estimation methods in answering forensic questions using SNP data of varying density, quality and population backgrounds.

## Toxicology

**Recipient:** Sam Houston State University

**The criminal justice problem:** Most forensic toxicology laboratories that perform routine criminal justice casework do not have in-house procedures for identifying synthetic cathinones in biological samples. Synthetic cathinone products are sometimes marketed as bath salts, plant food, insect repellant, pond cleaner, vacuum freshener or research chemicals. Many of the synthetic cathinone drugs are still unregulated because of the rapid introduction of new designer drugs. The structural alterations are sufficient to circumvent drug legislation, yet maintain the pharmacological properties desired by recreational drug users. These "legal highs" pose various issues, not only for law enforcement and public safety officials, but also for toxicologists who encounter these drugs in forensic investigations. New and improved methods of detection are needed for this new class of designer drug in forensic toxicology.

**The research:** Researchers at Sam Houston State University will develop a new analytical methodology to identify at least eight of the most prevalent synthetic cathinones in biological samples (blood and urine). They will investigate novel derivatives that are capable of derivatizing all synthetic cathinones, regardless of the side chain functionality that is routinely modified by clandestine chemists. This will include investigating a number of ketone-active derivatives, characterizing the derivatives spectroscopically, optimizing conditions and applying the new procedure in toxicology casework. Through collaboration with an accredited forensic laboratory, the researchers will apply the newly developed method to actual forensic toxicology casework samples.

**Recipient:** Research Triangle Institute (RTI)

**The criminal justice problem:** Every year, forensic laboratories in the U.S. are asked to analyze hundreds of thousands of controlled substances and drugs of abuse. This can result in backlogs that have budgetary and policy implications and could potentially compromise law enforcement investigations. Research is needed to develop technologies that can decrease analysis time and per-sample cost.

**The research:** Researchers at RTI will evaluate the applicability of the laser diode thermal desorption (LDTD) source (a new direct ionization source for mass spectrometry) in controlled substances and drug toxicology. They will evaluate the instrument's performance as a high-throughput source to detect controlled substances, including new emerging designer drugs, drugs used in drug-facilitated crimes and those relevant to post-mortem toxicology. This novel technology has the potential to significantly decrease both analysis time and per-sample cost. The LDTD source, coupled with mass spectrometry, has demonstrated its applicability in other scientific areas by providing data comparable to traditionally used instrumentation, such as liquid chromatography-tandem mass spectrometry, in less than half the time without the need for commonly used laboratory consumables such as analytical columns.

## Controlled Substances

**Recipient:** University of Central Florida

**The criminal justice problem:** There are often no definitive, highly presumptive tests for emerging substances of abuse (so-called designer drugs). This limits the effectiveness of collection and identification of evidence in incidents involving small quantities of substances of abuse.

**The research:** Researchers at the University of Central Florida will work on the development of rapid, high-sensitivity and low-cost methods for detecting substances of abuse. The work will focus on developing fluorescent indicators based on $d^{10}$ metal complexes that will allow greater detection sensitivity and flexibility. By coupling new sources, fluorescent indicators and digitizing systems, the researchers hope to enable a rapid positive identification of trace amounts of these compounds in the field and in the lab. The ultimate goal is to produce a rugged, multipurpose field test and trace kit that has a firm foundation of scientific understanding.