U.S. Department of Justice
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National Institute of Justice

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NATIONAL INSTITUTE OF JUSTICE

THE IMPACT OF NIJ FORENSIC SCIENCE RESEARCH AND DEVELOPMENT

NIJ

U.S. Department of Justice
Office of Justice Programs

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The National Institute of Justice is a component of the Office of Justice Programs, which also includes the Bureau of Justice Assistance; the Bureau of Justice Statistics; the Office for Victims of Crime; the Office of Juvenile Justice and Delinquency Prevention; and the Office of Sex Offender Sentencing, Monitoring, Apprehending, Registering, and Tracking.

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In crime labs across the United States, scientists and technicians are being armed with increasingly sophisticated technologies that they can use to help bring criminals to justice and prevent the innocent from going to prison. Just as medical research is crucial for advancing public health, sustained progress in forensic science — the application of physics, chemistry, biology, computer science, and engineering to matters of law — is critical for advancing public safety and the administration of justice.

The National Institute of Justice (NIJ) gathers information about criminal justice successes, failures, and needs directly from practitioners, policymakers, and scientists to help guide its research investments. Toward that goal, NIJ supports advances in forensic science through its Research and Development in Forensic Science for Criminal Justice Purposes program.

Since 2009, the National Institute of Justice has invested $255 million through its Forensic Science for Criminal Justice Purposes program, making it a global leader in the advancement of forensic science.

The Research and Development in Forensic Science for Criminal Justice Purposes program, which is the largest funding initiative at NIJ, has three goals:

1. Improve our understanding of the accuracy, reliability, and validity of forensic disciplines.
2. Increase the body of knowledge to guide forensic science policy and practice.
3. Produce novel and useful materials, devices, systems, and methods.

Forensic Science in Action

DNA Mixture Interpretation

Over the past decade, NIJ's forensic biology and DNA research and development portfolio has made nearly 20 awards to more than a dozen institutions for DNA mixture interpretation — the identification of individual DNA "donors" from a single biological sample. In 2017, researchers from Stanford University published their work on an innovative approach to DNA mixture interpretation. They took CRISPR (clustered regularly interspaced short palindromic repeats) technology, originally developed for gene editing, and adapted it to improve the interpretation of forensic DNA mixtures. This work highlights how NIJ embraces technology from other scientific communities to help revolutionize forensic applications.

Molecular Autopsy

A molecular autopsy is a forensic technique that can help determine the cause of unexplained death, particularly in cases of sudden death in infants and the young. NIJ has supported the New York City Office of Chief Medical Examiner's research on molecular autopsies since 2011. Most recently, the researchers were awarded funds to develop improved postmortem tests for genes that cause sudden unexplained deaths from epilepsy, fatal pulmonary embolism, and aortic dissection. In addition to being a cost-effective tool for cause of death determination, molecular autopsies can be life-saving for families with these inheritable genes.

E-Cigarette Research

NIJ has been supporting e-cigarette research projects since 2014. The latest studies have looked at e-cigarettes' potential for abuse using drugs other than nicotine, such as cannabinoids and other illicit substances. There have also been studies looking at the potential health concerns of vaping ethanol. Studies have shown e-cigarette liquids can contain ethanol concentrations as high as 23%. Not much is known about how ethanol consumed via vaping affects the user or possibly interferes with field sobriety tests.

Small-Molecule Testing for Substances of Abuse

Synthetic cathinones, stimulants commonly referred to as bath salts, can induce severe adverse effects, including death. Synthetic cathinones are structurally different from other drugs; therefore, traditional testing methods cannot detect them. NIJ-supported researcher Yi Xiao and her team at Florida International University recently developed an ultrasensitive, reliable, and portable method for detecting small molecules unique to synthetic cathinones. The new method can be used directly on seized substances or on biological samples like blood or saliva. The small-molecule detection method could also have applications in detecting other substances, including synthetic cannabinoids and opioids.

Identifying Lubricants Collected From Sexual Assaults

In 2016, NIJ supported researchers at the University of Central Florida to develop the sexual assault lubricant database, which provides a reliable standard for sample identification. In 2018, the Institute continued its support for the research team to develop guidelines for forensic laboratories to analyze unknown lubricant samples collected from sexual assaults. Ultimately, the researchers aim to make it possible for forensic professionals to compare a real-world sample of an unknown sexual lubricant with a known sample from the sexual assault lubricant database. The project also endeavors to develop forensic laboratory guidelines for collecting, storing, screening, and analyzing lubricant samples.

NIJ's Forensic Science Research and Development Program

The Institute is focused on research and development portfolios that support the vital role of forensic science in the criminal justice system.

Forensic Science Research

Through its funding of research and development, NIJ continues to advance the speed, accuracy, and scope of forensic analyses, which ultimately bolsters the administration of justice. The Institute supports projects in the following disciplines:

- Forensic Biology & DNA
- Seized Drugs
- Latent Fingerprints
- Firearms & Tool Marks
- Trace Evidence
- Forensic Toxicology
- Forensic Pathology
- Forensic Anthropology
- Bloodstain Pattern Analysis
- Crime Scene Examination
- Fire & Arson
- Forensic Odontology
- Footwear & Tire
- Questioned Documents
- Digital & Multimedia Evidence
- Wildlife Forensics

Novel psychoactive substances, like synthetic cannabinoids, are often difficult to identify with traditional tests. NIJ supports research into both identifying new substances of abuse and developing testing methods for these drugs.

Estimating time since death (postmortem interval) is important for medicolegal death investigations. NIJ-supported researchers are developing a new method for estimating time since death that sums 16 decomposition observations of the deceased instead of three observations. In a preliminary study, the new method outperformed the old method in more accurately predicting known time since death in 51 human donors.

Forensic analysis of fingerprints, firearms, shoe prints, and blood patterns traditionally depends on qualitative comparisons by experienced examiners. NIJ funds research to develop quantitative methods for these analyses that have solid scientific foundations and minimize human examiner bias.

Associated NIJ Programs

NIJ supports a family of other programs that advance forensic science research and the dissemination of knowledge.

Research and Evaluation in Publicly Funded Forensic Laboratories
The Institute promotes research at or in conjunction with laboratory personnel from publicly funded forensic science laboratories, including state, regional, county, municipal, and tribal agencies. Specifically, NIJ funds studies to identify the most efficient, accurate, reliable, and cost-effective methods for the identification, analysis, and interpretation of physical evidence for criminal justice. Since 2014, NIJ has awarded nearly $7.8 million to 29 projects.

Center for Advanced Research in Forensic Science
In 2014, NIJ and the National Science Foundation (NSF) established the Center for Advanced Research in Forensic Science (CARFS), which brings industrial partners and forensic science laboratories together with academic researchers to develop, implement, and commercialize tools to advance forensic science research. Since its founding, CARFS has awarded seed money to more than 40 projects at five universities. In September 2020, NIJ and NSF signed a new five-year memorandum of understanding that continues program support.

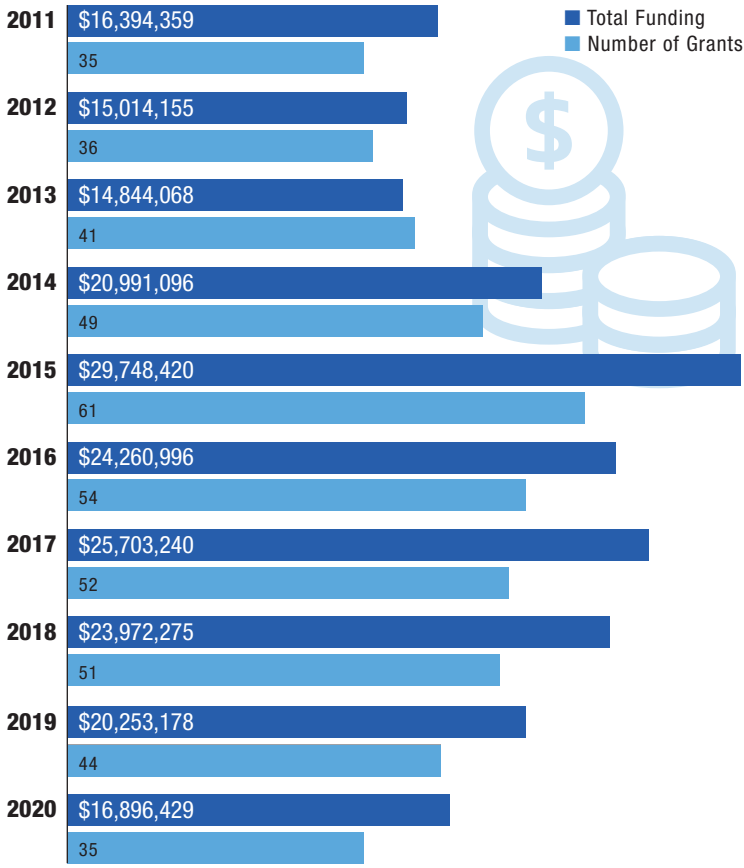
Graduate Research Fellowships in STEM
For more than 40 years, NIJ has supported doctoral students conducting research relevant to criminal justice. The Institute supports the next generation of researchers addressing problems affecting criminal justice policy and practice in the United States. Since 2014, NIJ has awarded 110 fellows stipend packages providing up to three years of support.

The Forensic Technology Center of Excellence
The Forensic Technology Center of Excellence (FTCoE) is supported by a cooperative agreement from NIJ and led by RTI International. FTCoE supports the implementation of new forensic technology and best practices by end users and is dedicated to elevating the status of forensic science through advancing technology and sharing knowledge. The Center has been bridging the gap between the scientific and justice communities at RTI since 2011.

Investing in Justice

NIJ is a global leader in funding forensic science research and development. Dollar amounts fluctuate annually because there is no dedicated funding source for the Research and Development in Forensic Science for Criminal Justice Purposes program. In order to support research activities, NIJ must draw from its base funding or transfer funding from Bureau of Justice Assistance forensic science laboratory capacity programs.

Research and Development in Forensic Science for Criminal Justice Purposes: Funding by Fiscal Year 2011-2020



Technology Transfer Success Stories

The Forensic Technology Center of Excellence is supported by a cooperative agreement with NIJ and led by RTI International. The center is focused on moving new forensic technologies from research to practice. Technology transfer success stories from the Center include:

Rapid DNA Analysis

Rapid DNA is a fully automated technique that can develop a DNA profile from a biological sample in 90 minutes. In theory, Rapid DNA can analyze a suspect's DNA before they leave police custody, compared with traditional tests that can take several months. In 2008, NIJ funded NetBio (now rebranded as ANDE) to research and develop the technology, and to pilot test Rapid DNA machines in select police booking stations. In September 2019, the FBI Washington Field Office performed the first upload and search of a Rapid DNA profile into its Combined DNA Index System (CODIS) as part of a pilot study. In May 2019, U.S. Immigration and Customs Enforcement successfully deployed Rapid DNA to the borders to help combat human trafficking.

"NIJ was the first group to really give us a chance, to believe that there was something to our vision, and the NIJ grants that were awarded were major building blocks in our development."

– Richard Selden, ANDE founder

Paper Microfluidic Devices for On-Site Residue Testing

Florida International University has developed a number of paper microfluidic devices for forensic residue analysis applications, including explosives, serological stains, and seized drugs. These devices are inexpensively printed in wax-based ink on chromatography paper and can produce clear results within five minutes. They can also be printed to simultaneously test for up to six different residues in a single sample. The devices have been validated by the Miami-Dade Bomb Squad and are being considered for commercial forensic applications.

"[These devices] have the potential to address challenges field forensics investigators encounter with non-pure, intermixed drugs as well as unknown powders."

— Michael Buerger, Professor of Criminal Justice, Bowling Green State University

3D Virtual Microscopy Standards for Firearm Forensics

Firearms evidence can link seemingly unrelated crimes or tie a specific gun to a crime scene. Firearm forensic analysis is done by a trained examiner who identifies firearms matches from the microscopic marks that are transferred to a cartridge case or bullet when the weapon is fired. This visual exam method is prone to variability due to lighting effects and human error, and delays can occur when physical evidence is transferred to the examiner. Since 2012, NIJ has supported Cadre Research Labs' development of a novel imaging system for measuring the 3D surface topography of firearms evidence. The technology has been validated for use in casework in the FBI Laboratory's Firearms Unit. NIJ has also funded the National Institute of Standards and Technology to develop measurement standards and research databases necessary for firearms examiners to make accurate statements about the strength of the identifications they present in court.

"High-resolution 3D surface topographies coupled with advanced software analysis are providing firearm examiners unprecedented new tools for microsurface examination."

— Ryan Lilien, Chief Scientific Officer, Cadre Forensics

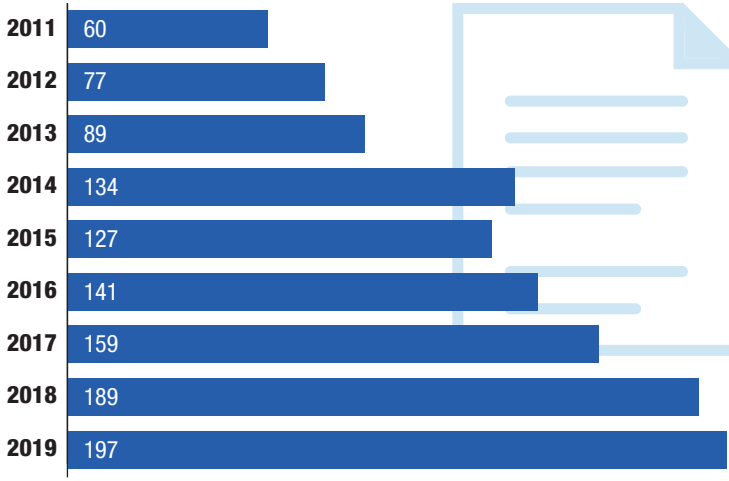
Measurable Impact on the Field of Forensic Science

NIJ-sponsored researchers are expected to make quantifiable impacts on their field of expertise. Their contributions are measured in part by the dissemination of their work through peer-reviewed publications and through patents.

Publications

Since 2011, researchers sponsored by the Research and Development in Forensic Science for Criminal Justice Purposes program have published over 1,300 papers in more than 150 peer-reviewed journals, including *Forensic Science International, Journal for Forensic Sciences, Nature, PNAS,* and *Analytical Chemistry.*

Publications by Researchers Supported by NIJ Research and Development in Forensic Science for Criminal Justice Purposes Funding, 2011-2020



The most cited paper from NIJ-supported researchers is "A Global Reference for Human Genetic Variation," which offers a more complete picture of human diversity by sequencing genomes from small, diverse populations. The paper was published in *Nature* in 2015 and has been cited in more than 5,100 other papers.

Patents from NIJ-Sponsored Research

Research teams supported by NIJ's Research and Development in Forensic Science for Criminal Justice Purposes program filed and received several patents from the U.S. Patent and Trademark Office in 2020, including:

Recovering Defaced Serial Numbers on Firearms

An NIJ-funded research team at Idaho State University filed U.S. patent 10,657,413 in 2020 for a nondestructive infrared thermal imaging method for recovering defaced serial numbers on firearms. Serial numbers are stamped or laser-etched onto a gun for identification purposes but can be scratched off by criminals trying to make the weapon difficult to trace. In some cases, the serial numbers can be restored with chemical etching, but law enforcement officials prefer techniques that do not destroy potential evidence. Both stamping and etching serial numbers on firearms strain and distort the atomic structure of the metal beneath the numbers. Infrared thermal imaging can trace these differences in thermal conductivity, and when combined with digital imaging enhancement, it can reveal the removed serial numbers.

Dissolving Swabs for Improved Sample Collection

A team from GE Global Research and the University of Akron received U.S. patent 10,598,577 for a photo-dissolvable swab that enables efficient recovery of trace amounts of DNA from biological samples. The photo-dissolvable swab is made from polyhydroxyethyl acrylic polymer fibers and functions in the same manner as a regular swab during sample collection. However, the swab completely degrades when exposed to DNA-friendly 365 nm wavelength ultraviolet light. By dissolving the swab directly into PCR sample extraction buffers, lab personnel can amplify trace amounts of DNA picked up by the swab without having to extract or pre-concentrate it. The researchers are also developing an ultraviolet-breadboard light for faster degradation of the swabs' photo-dissolvable polymers.

Detecting Source of Body Fluid

U.S. patent 10,619,218 was issued to researchers from Florida International University for the development of biomarkers to identify the source of body fluids from crime scene samples. DNA profiles can place a suspect at a crime scene, but they cannot discriminate innocent from criminal contact. In cases of sexual abuse of minors, the innocent transfer of DNA from skin is expected from close relatives, but DNA from intimate body fluids indicates abuse. The researchers looked to DNA methylation analyses (the melting characteristics of DNA) of specific genome locations that regulate tissue-specific gene expression for blood, saliva, and semen. By using readily available real-time high-resolution DNA melt instrumentation, they were able to quickly and affordably discern a body fluid sample as blood, saliva, or semen by analyzing its methylation pattern.

Single-Step Detection of Synthetic Cannabinoids

NIJ supported researchers at Florida International University to develop a rapid and accurate single-step test for synthetic cannabinoids in biological or seized samples. The invention, described in U.S. patent 10,907,163, includes the production of aptamers – short, single-stranded RNA or DNA molecules – that bind to specific small molecules in synthetic cannabinoids and aptamer-based sensors. The researchers say aptamer tests are a better choice for detecting synthetic cannabinoids than commonly used antibody tests because they are more specific, less expensive to produce, easier to modify, more chemically stable, and have a longer shelf-life. With thousands of synthetic cannabinoids currently on the market and new variations continuously emerging, aptamer testing could help keep up with synthetic cannabinoid evolution and regulation.

Patents

NIJ-supported forensic science researchers have filed and received over 60 patents from the U.S. Patent and Trademark Office since 2011.

U.S. Patents Awarded to Researchers Supported by NIJ Research and Development in Forensic Science for Criminal Justice Purposes Funding, 2011-2020

Learn more about NIJ's forensic science portfolio, including how NIJ identifies research priorities, addresses forensic casework backlogs, and studies the impact of forensic science on the criminal justice system.

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