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NATIONAL INSTITUTE OF JUSTICE

# THE IMPACT OF FORENSIC SCIENCE RESEARCH AND DEVELOPMENT



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**FORENSIC SCIENCE**  
RESEARCH AND DEVELOPMENT

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# THE IMPACT OF FORENSIC SCIENCE RESEARCH AND DEVELOPMENT

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. Innovations from forensic science research and development (R&D) are bringing new techniques to crime solving and increasing the reliability and efficiency of forensic testing.

Just as medical research is crucial for advancing public health, sustained progress in the research underlying forensic science is critical for advancing public safety and the administration of justice.

Strengthening science to improve justice is a key goal of the National Institute of Justice (NIJ). Toward that goal, NIJ funds both basic and applied forensic research.

**Since 2009, the Institute has invested more than \$127 million in an R&D portfolio that makes it a global leader in the advancement of forensic science.**

In addition, NIJ maintains partnerships with the National Science Foundation (NSF) and the National Institute of Standards and Technology (NIST) to promote innovation in forensic science. In 2014, NIJ and NSF jointly initiated an Industry/University Cooperative Research Center to advance university and industry collaboration in forensic science R&D and in education.

One of several NIJ-NIST working groups has developed best practices for the handling and preservation of DNA and other biological evidence. Other working groups in the partnership are addressing the interoperability of regional and national automated fingerprint identification systems (AFIS); developing procedures to limit investigator bias in examining fingerprints; and creating examination standards for a variety of evidence types in criminal cases.

## Strengthening Crime Laboratories

Forensic science R&D in the 1980s laid the groundwork for advances in the 1990s and early 2000s that had a profound impact on crime laboratories. Although the scientific advances, particularly the growth of DNA testing, provided more effective tools for analyzing evidence and identifying perpetrators, they also led to a dramatic increase in the demand for lab services. By the late 1990s and through the 2000s, demand outstripped the ability of the labs to respond quickly and efficiently. Today, scientists and technicians at forensic labs are under relentless pressure to produce results faster and at lower cost. NIJ employs a two-pronged approach to supporting forensic labs:

- In the short term, NIJ awards grants to labs that cover the increasing costs of processing cases, assist in DNA backlog reduction and support ongoing efforts to adopt more advanced instrumentation and analytical methods.
- In the long term, NIJ awards grants to scientists to conduct research, both basic and applied, that can lead to methods, techniques and technology that will advance forensic science and, ultimately, public safety and justice.

Innovation is an essential way to assist crime labs. For example, high-tech robotic workstations can now process large numbers of DNA samples simultaneously, allowing crime labs to work more efficiently. NIJ-supported research helped in the development of fully automated systems that amplify DNA from small samples to determine a person's genetic profile. The workstations not only make labs more efficient but also lower the cost of DNA processing.

NIJ is also funding several projects that seek to apply more sophisticated methods to detect and analyze evidence. Examining evidence for trace amounts of blood or other biological material is time consuming for law enforcement and crime lab personnel, and it requires techniques that can compromise or destroy evidence. One NIJ-funded project involves developing a camera with multispectral and fluorescence imaging capabilities to detect and identify fingerprints, body fluids, stains and other residues at crime scenes. Such imaging technology would make it easier for investigators to find and process evidence while minimizing evidence contamination.

Researchers working on another NIJ-supported project are developing methods that will allow investigators to identify the body fluids in a stain without destroying any of the stained material. Researchers are also exploring how to use one sample to determine multiple pieces of information, such as body fluid type and genetic information associated with identity.

## Advancing Forensic Technology in the Field

Law enforcement investigators, as well as scientists and technicians in crime labs, must rely on new technologies and scientific innovations to more efficiently identify, gather and process evidence related to criminal activity. The NIJ portfolio covers a wide range of forensic science disciplines, both for investigators in the field and for scientists in the lab.

### Identifying Drugs in the Field

Researchers working on a current NIJ-supported project are developing a simple yet sophisticated device that may soon allow law enforcement personnel to quickly identify illegal drugs using a handheld fluorometer and a smartphone. The fluorometer, constructed for about \$45 with a 3-D printer, allows investigators to identify powders and other substances using a paper test strip soaked in copper iodide. Certain classes of drugs react with the copper by giving off a fluorescent light signature unique to the drug. An investigator in the field can photograph the fluorescence spectrum with a smartphone, upload the results to the Cloud, compare it to known spectra in an online database for identification, and use that information in building a criminal case. According to the lead researcher, the system requires only a small amount of the drug for testing and has not shown false positive readings.

### Validating the Accuracy of Firearm Examiners

Since 2009, NIJ has supported studies to determine the accuracy and reliability of firearm and toolmark examinations. In a recent collaboration between the Miami-Dade Police Department and researchers at Florida International University, scientists tested the accuracy of firearms examiners' analysis of evidence.

The researchers found that firearms examiners had an average error rate of less than 1.2 percent. The experiment used bullets fired from 10 consecutively manufactured Glock barrels with the same EBIS (Enhanced Bullet Identification System — an etched-barrel barcode system) pattern. These comparisons, which used bullets fired from barrels intentionally made as similar as possible, were designed to be among the most challenging that an examiner could face. The research team distributed 150 test sets to 165 firearms examiners in 41 states, the District of Columbia and four other countries. A test set consisted of one known bullet test-fired from each barrel, plus 10 unidentified bullets drawn from the test fires. This was the largest sample size ever used for this type of experiment. Most examiners recorded no incorrect answers, and the average examiner rate was less than 1.2 percent. The researchers found no significant difference in error rates between examiners with more than 10 years of experience and those with less experience.

The growing demands for evidence processing in recent years have clearly shown that labs must move to more efficient and sophisticated methods and procedures. Scientific and technological advances made possible through strong support for research will be essential to ensuring that crime labs keep pace with increasing demand.

### Assisting Law Enforcement

Scientific advances already play an important role in solving crimes. Labs can analyze smaller pieces of evidence than ever before, and law enforcement officials can gain valuable information from evidence that, in the past, would have been degraded and unusable due to weathering or time. New technology also allows investigators to find and analyze evidence that they would likely not have found via earlier methods. One example of this increasingly sophisticated technology is a method that could help forensic scientists analyze dust and other particles that piggyback on carpet fibers to determine whether fibers found in different locations are consistent with having originated from the same source. In some instances, such a comparison could provide investigative leads associating a suspect or victim with a crime scene.

Investigators can now use DNA and other evidence collected and stored decades ago to help identify and convict criminals who have eluded authorities for years and to exonerate prisoners who were wrongly convicted before today's more sophisticated methods became available. A striking example of new technology solving a cold case occurred in 2009, when Milwaukee police tested evidence in a reopened case and eventually linked nine murder cases dating back to 1986. They identified Walter Ellis as the suspect in what were known as the North Side Strangler cases. Faced with the new evidence, Ellis pleaded "no contest" to charges that he strangled seven women. In 2011, he was sentenced to seven life terms with no chance of parole.

One of the more difficult challenges facing police officers working in the field today is accurately identifying substances that may be illegal drugs. This problem has grown in recent years with the widespread use of ever-evolving novel psychoactive substances, such as "bath salts" and synthetic cannabinoids, which are specifically created not only to mimic the effects of other drugs but also to avoid being classified as illegal.

These drugs can be extremely difficult to identify, and NIJ has responded to the problem by funding several projects focused on developing more accurate methods of identifying the parent drugs (the drugs as ingested into the body) and their metabolites (the forms of drugs after being processed by the body). The goal of the research is to make drug identification faster, easier, safer and more accurate. One study aimed at improving identification of drugs and their metabolites involves obtaining blood, urine and oral fluid samples from volunteers at electronic dance music festivals who have ingested drugs.



## Confirming the Accuracy of Bloodstain Pattern Examiners

Crime scenes can present a variety of bloodstain patterns on assorted surfaces. To verify examiners' accuracy in determining what happened at a crime scene based on a particular pattern, scientists asked analysts to review more than 700 patterns falling within six different pattern types. Generally, the results indicated that bloodstain pattern analysts had lower error rates when classifying patterns on rigid surfaces than when classifying patterns on fabric surfaces (13 percent vs. 23 percent). These rates varied by pattern type, and some patterns were more reliably classified than others. Researchers also found evidence of confirmation bias, meaning that when analysts were given a scenario that pointed deliberately toward the correct classification, they were more likely to select that classification for the bloodstain pattern.

These results indicate that more work is needed to understand how the interaction of blood with different surfaces influences the observed patterns. NIJ has ongoing investments in fluid dynamics research with the goal of providing examiners with objective computational tools to assist in their analyses. In addition, the results of the bias study indicate that crime labs and law enforcement agencies should take steps to minimize extraneous information that analysts receive before they conduct an analysis.

## Examining Human Factors in Fingerprint Analysis

The accuracy of latent print examinations and the extent of human error in fingerprint analysis have also been the subject of recent studies in the justice system. NIJ is funding experts who are examining the effect of human error in fingerprint analysis, especially the tendency to focus on data that confirm preconceived expectations. One of the early recommendations from the experts is that crime labs develop a "culture of openness" in which errors are identified, acknowledged and used to improve analysis and reduce the error rate.

## Standardizing Broken Glass Analysis

Broken glass at a crime scene can often be important evidence for investigators. In hit-and-run crimes, for example, examiners can analyze glass fragments to see whether the characteristics of the fragments are consistent with samples taken from a suspect's car. A team of scientists has developed two new standards for forensic glass analysis to ensure that testing is administered consistently in different labs.

## Helping the Public

Ultimately, forensic science R&D is conducted to improve public safety and ensure that justice is fairly applied. For NIJ, that means improving the information available to all parties as a crime is investigated and prosecuted. For example, new forensic techniques to help identify human remains not only can assist authorities in apprehending the perpetrator but also can provide some resolution to the victim's family.

With NIJ funding, scientists are developing more effective ways to identify bodies and pinpoint the time of death. Forensic anthropologists, for example, are mapping craniofacial features with 3-D imaging to help determine the ancestry of individuals and using radiographs to more precisely estimate the age at death for juveniles.

The advanced science and innovative technology currently in use in the nation's crime labs are the direct result of R&D conducted in the past. Through its funding of forensic science R&D, NIJ will continue to improve the speed, accuracy and scope of crime lab evidence analysis and ultimately strengthen the administration of justice.

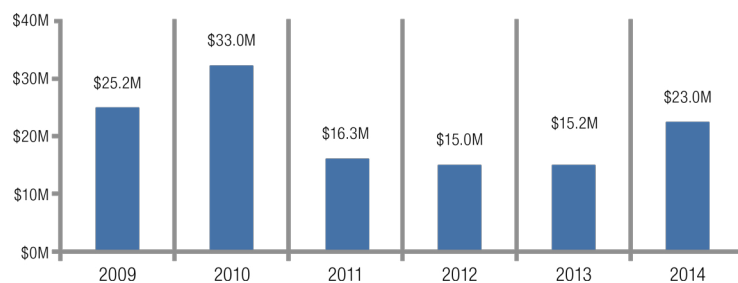
## Funding Forensic Science Research and Development

NIJ's investment in research is strengthening science and enhancing justice. It is the Institute's most enduring contribution to forensic science.

Since 2009, NIJ has funded forensic science projects worth more than \$127 million, including approximately \$116 million for 269 research awards and nearly \$11 million for projects by federal partners. This funding has resulted in more than 900 reports, publications in scholarly journals and presentations. More than \$23 million of that funding was invested in fundamental forensic research in direct response to the recommendations of the 2009 National Academies report *Strengthening Forensic Science in the United States: A Path Forward*, available at [NCJRS.gov](http://NCJRS.gov), keyword: 228091. Figure 1 shows funding by fiscal year.

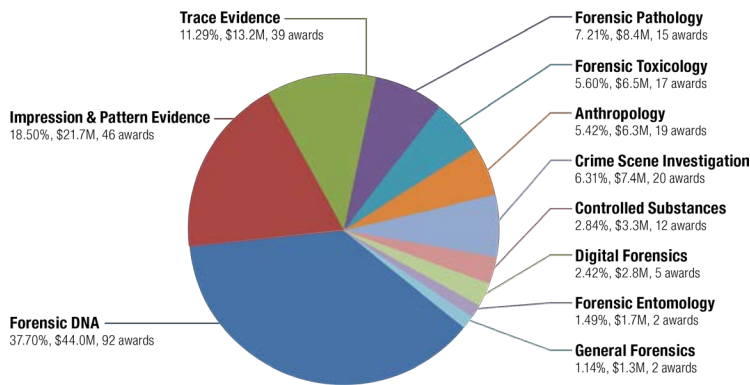
**Figure 1. Funding by Fiscal Year**

Total Funding: \$127,650,471



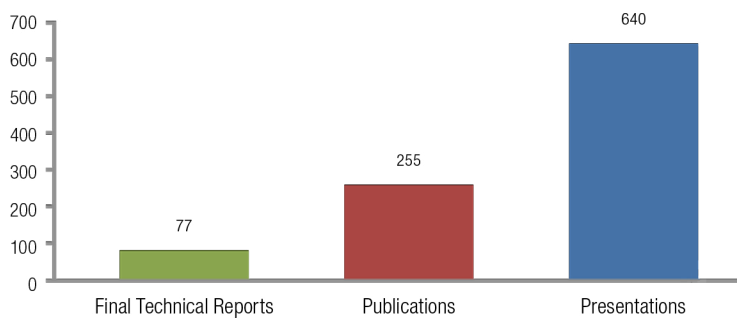
Forensic science is, at its base, the application of science to matters of law. Forensic research encompasses a wide range of fields, including biology, chemistry, physics and anthropology. Figure 2 shows the overall distribution of funding categories for research awards.

**Figure 2. Distribution of Funding for Research Awards by Discipline**



NIJ uses information reported semiannually by recipients of R&D funding to assess the technical and programmatic progress of projects. One way that NIJ evaluates the reach and impact of its research is to track dissemination activities such as publications and presentations at meetings and conferences. Figure 3 shows dissemination reported through July 2014 for projects funded between 2009 and 2013.

**Figure 3. Grantee Dissemination Activities**



Publications include all peer-reviewed articles in academic journals, abstracts published in conference proceedings and other sources based on numbers reported by grantees. This number does not include grantees' self-reported articles "accepted" for publication and articles published through media outlets.

### Appendix: Solicitations for Forensic Science Research and Development

Through funding for external research, NIJ's forensic science research and development program seeks to increase the body of knowledge necessary to guide forensic science policy and practice. Funded projects are producing useful materials, devices, systems and methods that have the potential for forensic application, as well as developing further fundamental understanding of the science underlying the forensic science disciplines.

Between 2009 and 2014, NIJ issued 23 solicitations inviting proposals for research and development projects related to forensic science. NIJ awarded a total of \$116,670,798 to fund 269 research projects. Learn more about these projects at [NIJ.gov](http://NIJ.gov), keywords: forensic awards.

Fiscal Year	#	Solicitation Title
FY 2009	1	Forensic DNA Research and Development: Invited Full Proposals
	2	Research and Development in the Forensic Analysis of Trace Evidence: Invited Full Proposals
	3	Research and Development on Impression Evidence: Invited Full Proposals
	4	Fundamental Research to Improve Understanding of the Accuracy, Reliability, and Measurement Validity of Forensic Science Disciplines
	5	Directed Funding for Forensic Science Research, Development and/or Evaluation
FY 2010	6	Research and Development on Instrumental Analysis for Forensic Science Applications
	7	Research and Development on Forensic Crime Scene and Medicolegal Death Investigations
	8	Research and Development on Pattern and Impression Evidence
	9	Forensic DNA Research and Development
	10	Fundamental Research to Improve Understanding of the Accuracy, Reliability, and Measurement Validity of Forensic Science Disciplines
	11	Directed Funding for Forensic Science Research, Development and/or Evaluation

FY 2011	12	Applied Research and Development in Forensic Science for Criminal Justice Purposes
	13	Basic Scientific Research to Support Forensic Science for Criminal Justice Purposes
	14	Directed Funding for Forensic Science Research, Development and/or Evaluation
FY 2012	15	Applied Research and Development in Forensic Science for Criminal Justice Purposes
	16	Basic Scientific Research to Support Forensic Science for Criminal Justice Purposes
	17	Directed Funding for Forensic Science Research, Development and/or Evaluation
FY 2013	18	Applied Research and Development in Forensic Science for Criminal Justice Purposes
	19	Basic Scientific Research to Support Forensic Science for Criminal Justice Purposes
	20	Directed Funding for Forensic Science Research, Development and/or Evaluation
FY 2014	21	Research and Development in Forensic Science for Criminal Justice Purposes
	22	Research and Development for Publicly Funded Forensic Science Laboratories to Assess the Testing and Processing of Physical Evidence
	23	Directed Funding for Forensic Science Research, Development and/or Evaluation

### Evolution of the NIJ Research and Development in Forensic Science Solicitation

In 2009, NIJ announced the creation of the Fundamental Forensic Science Research portfolio and solicited proposals for projects seeking to improve understanding of the accuracy and reliability of methods used to analyze evidence. In 2011, to further support research in the physical, life and cognitive sciences underlying the forensic science disciplines, NIJ created the Basic Scientific Research solicitation while focusing its applied research and development mission into a separate, concurrent solicitation. In 2014, basic, fundamental, and applied research and development proposals were all invited through a single combined forensic research solicitation that made no distinction between types of research.