

Professional Review and Commentary^a

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Forensic Science Review's Professional Review and Commentary (R&C) section highlights contemporary issues and events in the profession of forensic science. To contribute updates or commentary or to recommend books for review, please contact Mike Baylor (mbaylor@nc.rr.com), Jeff Teitelbaum (Jeff.Teitelbaum@wsp.wa.gov), or Ray Liu (rayliu@uab.edu).

^aThe views expressed are those of the authors and do not necessarily reflect the view, the position, or the policy of *Forensic Science Review* or members of its editorial board.

Forensic Science in UK. Part I: Historical Development and Current Status

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This commentary is the first in a three-part series discussing the origins of forensic science provision in the UK and how this has developed over time to its present form. The focus of this first part is historical development, with emphasis on the now defunct Forensic Science Service (FSS). The current commercial provision in England and Wales is overseen by the Forensic Science Regulator (FSR), parallel to the system in operation in the US with the National Institute of Standards and Technology (NIST)/ National Institute of Justice (NIJ) working out mechanisms and methods for improvements. The second part of this series will focus on approaches adopted (and achievements reached) by the FSR; the third part will describe forensic science provision in Scotland and Northern Ireland.

The History of the Forensic Science Service in England and Wales

The first forensic science laboratories were developed by police forces, with the first laboratory being opened in 1910 in Lyon, France [1]. The first police laboratory in the UK was the Metropolitan Police Laboratory that opened in 1935 at Hendon (a London suburb in the Borough of Barnet) with a staff of six. Following this, the Home Office established a number of regional laboratories across England and Wales under the name of the Home Office Forensic Science Service (HOFSS) [2]. Prior to 1991 the HOFSS consisted of six regional laboratories sited in Aldermaston, Birmingham, Chepstow, Chorley, Huntingdon, and Wetherby, plus the Metropolitan Police Forensic Science Laboratory (MPFSL) in London. Initially the laboratories were directly funded by the treasury, later moving to a capitation charge from each police force according to its size [2].

In 1991 the FSS was formed as an executive agency of the Home Office by merging the regional laboratories into a single organization. The funding model was changed

to a direct charging system where services were provided on a contract or a case-by-case basis. The intention was not to create a market for forensic science services but to give police forces the freedom to be able to spend more of their budgets on forensic services [3]. In 1996 the FSS merged with the MPFSL, the largest forensic laboratory in the UK, to form a single organization serving the 43 police forces of England and Wales and in 1999 the FSS acquired Trading Fund status [1].

The FSS laboratories continued to provide services to their local police forces but specialist expertise was developed in particular laboratories and so a comprehensive national service was now available. Trading Fund status allowed the FSS to generate its own income by selling its services to any customer in the UK or abroad. When the FSS was providing forensic services to both the prosecution and defense in the same criminal cases, this work was kept separate and confidential by carrying it out in different laboratories [1].

The Laboratory of the Government Chemist (LGC) and the Defence Science and Technology Laboratory (DSTL) were government laboratories that became agencies and entered the forensic science market offering specialist services. Private organizations also saw the opportunity to compete for the forensic science market with the most notable in this period being the formation of Forensic Alliance Ltd. in 1996 [1]. These companies penetrated the market, but the FSS remained the preferred supplier of the Association of Chief Police Officers (ACPO) until 2002 [4].

In 2002 the McFarland Review considered the emergence of a competitive forensic science market, the entrenched monopoly of the FSS, and the competitive disadvantage to the FSS of Trading Fund status; it recommended that the FSS should move to a public-private partnership (PPP) company with an interim period as a government-owned company (GovCo) [5]. In 2005, FSS Ltd. was formed as a wholly owned GovCo with the intention of transition to a PPP [4].

Police forces also carried out some areas of forensic science, namely crime scene investigation and fingerprinting. The forces typically employed scientific support managers, scene-of-crime officers (SOCOs), and fingerprint specialists. In 2004, it was estimated that 52% of police expenditure on forensic science was on in-house provision of fingerprinting and SOCOs, with the remaining 48% spent on external providers. Of this, 45% was spent

on provision from the main external providers at the time, namely the FSS, LGC Ltd., Forensic Alliance Ltd., and a number of smaller companies offering specialist analytical work. The remaining 3% was provided by individual forensic practitioners, for a total external-provision expenditure of £190 million. Of this, 85% was delivered by the FSS, at the time consisting of seven laboratories and more than 2,500 staff [4].

The transition of the GovCo to a PPP did not occur as no progress was made in reducing the cost base of the FSS and making it competitive in the growing commercial forensic science market. The decision was taken in 2010 to wind up FSS Ltd. in March 2012. Its market share had fallen to 60% of forensic services in England and Wales [6].

England and Wales has seen a transformation from a fully public-funded forensic provision to the commercial market in operation today, whereas provision in Scotland and Northern Ireland has remained publicly funded. In Northern Ireland, the first forensic science laboratory was opened in 1956 and was known as the Department of Industrial and Forensic Science. This was later renamed the Northern Ireland Forensic Science Laboratory, which became an executive agency of the Northern Ireland Office in 1995. The name was changed to Forensic Science Northern Ireland in April 2000, a name that it still retains today as an agency within the Department of Justice.

Forensic science services in Scotland were provided by four laboratories in Aberdeen, Dundee, Edinburgh, and Glasgow. In 2007 an integrated corporate scientific service was created by pulling together the forensic, fingerprint, and SOCO units into one organization called the Scottish Police Services Authority [1].

Final Closure of the Forensic Science Service

On March 31, 2012, the FSS, employing around 1,600 people, was finally closed to avoid the system entering into administration and jeopardizing the different ongoing criminal procedures it was involved in at the time. The reasons behind its closure and given to the public at the time were merely economic, as it was calculated the service was losing some £2 million a month. Talking to government officials active at the time, it is also clear the government also tried to avoid the duplication of knowledge that was happening as many police forces were also developing their own labs and testing samples. Limited resources forced the measure and also allowed decentralizing some of the services offered by the FSS by opening the market even more to forensic companies that were already making up for 40% of the forensic analyses at the time.

A cross-party House of Commons Science and Technology Committee published an inquiry report in July 2011 concluding that the government had not given sufficient thought to the real impacts of the FSS closure. These involved the implications for the criminal justice, research, and evidence archives held in FSS facilities. The government response to minimize these impacts involved making case files and samples available for their use in court and in cold cases with an annual cost to the Home Office of £2 million. The quantity of material destroyed as part of the closure has not been quantified and the official response of the government was that only duplications of existing material, out-of-date information with limited value, or items that were not considered to be required for casework support purposes and considered of no future value to the criminal justice system had been destroyed. In 2013, a government response [8] to the second report from the House of Commons Science and Technology Committee commenting on the impact of the FSS's closure defended that the transition was well managed in terms of maintaining quality standards and no forensic work was transferred from the FSS to unaccredited forensic providers.

Another criticism denied by the government was the lack of transparency and consultation carried out before deciding to close the FSS, arguing the need for a quick solution that could solve the serious legal and financial situation the FSS was facing and protecting the criminal justice system.

The measure to wind down the service is estimated to be £61 million in terms of staff redundancy payments and less than £100 million in cash terms. The precise figure depending on the final cost of lease exits and the receipts from the sale of freehold assets was not made public under a request under the Freedom of Information Act in 2012. The transition was managed by the Police and the National Policing Improvement Agency (NPIA) in a project known as "Operation Slingshot". This operation involved re-tendering some FSS services to police forces and was completed by October 2011.

For the police force, the dismantling of the FSS implied the loss of personal contacts and relations built over years and the possibility of the "quick ring" to discuss specific problems. Police forces when consulted commented on the loss of a more direct and regular contact and sometimes critical information and links to discuss intelligence and operational issues on a regular basis. Also, reports and guides made available to police forces on different issues are no longer available. The general feeling in some forces was that the system went back to that time when police used to solve their own problems individually.

Current Forensic Science Provision in England and Wales

The present situation of forensic science in England and Wales (as Scotland and Northern Ireland have autonomy on this) has not been fully solved yet. In March 2016, the Home Office published its Forensic Science Strategy for England and Wales, but a recent parliamentary report from the House of Commons Science and Technology Committee [9] has studied the situation and some of the conclusions drawn imply that the forensics strategy is missing a coherent vision for forensic services and a route-map to deliver it. Private laboratories and police forces cover the analysis and forensic provision at present, but talks are being held on whether there is a need to bring the FSS back [10].

At present, a key figure in the way forensic science is organized in England and Wales is the FSR (created by the government in 2008 and operating independently from the Home Office although sponsored by this organization), which ensures that the provision of forensic science services across the criminal justice system is subject to appropriate regimes and scientific quality standards. The FSR aims to:

- Make sure the correct standards are delivered appropriately to meet the needs of the criminal justice system;
- Advise and guide the forensic science providers, ministers, and others;
- Ensure effective means to investigate quality failures, and collaborate nationally and internationally to keep UK-wide quality standards.

The FSR is supported by a team of civil servants with additional support provided by the Home Office, as well as a Forensic Science Advisory Council (FSAC).

Also key, the quality standards used in forensic science are those lying under the norm ISO/IEC 17025 and those forensic providers willing to develop work for the police or the forensic services need to be accredited by the UK Accreditation Service (UKAS). The UKAS accreditation provides assurance of the technical competence of a laboratory to undertake specific analysis. It also reviews different areas relevant to the criminal justice system such as continuity of evidence, management of case files, and storage of exhibits. The UKAS makes sure the staff developing the essays are competent and qualified to do so, methods are robust and suitable, equipment is appropriate and kept and maintained adequately, and internal and

external quality controls are implemented. All private forensic science providers contracted to provide services must be accredited. However this same principle does not apply to police forensic laboratories, which has proven to be controversial.

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Changes to the Mandatory Guidelines for US Federal Workplace Drug Testing Programs Using Urine

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The US Department of Health and Human Services (HHS) has revised the Mandatory Guidelines for Federal Workplace Drug Testing Programs Using Urine (HHS Guidelines), effective October 1, 2017 [1]. This article summarizes the major changes to the previous HHS Guidelines, which were effective October 1, 2010.

Background

The US Government prohibits illicit drug use by federal employees, whether on- or off-duty. Federal law requires each executive federal agency to have a Drug-Free Workplace Plan stating the agency's objectives, policies, procedures, and implementation guidelines to prevent illicit drug use by their employees and to provide support to employees with substance abuse problems. Drug testing is an essential component of each agency's comprehensive program to ensure a drug-free federal workplace. HHS is responsible for establishing the scientific and technical guidelines for federal drug testing programs as well as the National Laboratory Certification Program (NLCP), the accreditation program for forensic toxicology laboratories to become certified to test federal agency workplace specimens. Within HHS, these responsibilities are assigned to the Division of Workplace Programs in the Substance Abuse and Mental Health Services Administration (SAMHSA).

Federal agencies must conduct random drug tests of employees in safety-sensitive positions. The frequency of and criteria for such testing depend on the agency's mission and goals, as well as the potential threat to public health, safety, or national security should the employee fail to discharge their duties. Agencies must also have a program for voluntary employee drug testing, and must test employees for illegal drug use when there is a reasonable suspicion that an employee is using drugs, after an accident, or following counseling or rehabilitation for illegal drug use. In addition, agencies are authorized to conduct pre-employment drug tests of applicants for any agency position.

General Requirements

The HHS Guidelines address all areas of a drug testing program, from collection through laboratory testing to medical review officer (MRO) review and verification of results. First published in 1988, the HHS Guidelines have become the gold standard for workplace drug testing programs. All federal agencies are required to follow the HHS Guidelines. In addition, the Department of Transportation (DOT) is required by law to follow the HHS scientific and technical guidelines in its drug testing regulations for transportation industries, and DOT-regulated testing must be conducted only by HHS-certified laboratories [2]. The Nuclear Regulatory Commission, many states, and private employers have chosen to use some or all aspects of the HHS Guidelines in their workplace drug testing programs.

Specimens submitted for testing under the HHS Guidelines must undergo initial drug testing, and those specimens with positive initial test results must undergo a confirmatory test to identify and quantify specific drug analyte(s). The HHS Guidelines specify the drugs that a federal agency may test routinely (i.e., in all specimens), and specify the initial and confirmatory drug test analytes and cutoff concentrations. A federal agency may test all workplace specimens for the specified drugs or, at a minimum, must test specimens for marijuana and cocaine. An agency is also authorized to test postaccident and reasonable suspicion specimens for any drug classified as Schedule I or II under the Controlled Substances Act [3]. In addition, an agency may request a waiver from HHS to test all specimens for any Schedule I or II drug.

In addition to testing for drugs, the HHS Guidelines specify the specimen validity tests that must be performed for each specimen, to identify specimens that are not valid for testing and those that may have been adulterated or substituted by the donor. The required specimen validity tests include determining creatinine concentration, determining the specific gravity of each specimen with creatinine less than 20 mg/dL, determining pH, and performing tests for one or more oxidizing adulterant (e.g., nitrite, chromium, a halogen).

At this time, urine remains the only authorized specimen type for federal workplace drug testing programs. On May 15, 2015, HHS published two Federal Register Notices with proposed HHS Guidelines: the Mandatory Guidelines for Federal Workplace Drug Testing Programs Using Urine (UrMG) and the Mandatory Guidelines for Federal Workplace Drug Testing Programs Using Oral Fluid (OFMG) [4,5]. This article addresses the final UrMG, published in the *Federal Register* January 23, 2017, with

an effective date of October 1, 2017. HHS has not yet published the final OFMG authorizing the use of oral fluid in federal workplace drug testing programs.

Summary of Major Changes

Alternate Technology Initial Drug Tests. Since the original HHS Guidelines were issued in 1988, HHS had required immunoassay as the sole initial drug test method. The UrMG allows the use of other technologies (e.g., spectrometry, spectroscopy) for initial drug tests. HHS also added cross-reactivity criteria for an immunoassay for “grouped analytes” such as opioids or amphetamines.

The UrMG (Section 3.4) defines grouped analytes as “two or more analytes that are in the same drug class and have the same initial test cutoff.” The laboratory must calibrate the immunoassay with the analyte identified by the kit manufacturer as the target analyte. The cross-

reactivity to all other “nontarget” analytes in the group must be 80% or greater. If an analyte does not exhibit at least 80% crossreactivity, the laboratory must use a different immunoassay or multiple immunoassay kits. The intent was to enable consistent treatment of specimens tested using immunoassay and those tested using an alternate technology.

Drug Test Analytes. The UrMG includes a table specifying the initial and confirmatory drug test analytes and cutoff concentrations for the authorized drugs (*see Table 1*).

In the UrMG, HHS has added four semisynthetic opioids (i.e., oxycodone, oxymorphone, hydrocodone, and hydromorphone) to the drugs that may be routinely tested by federal agencies. The addition of these four prescription opioids to the testing panel is consistent with the federal government’s actions to combat the current opioid epidemic in the US. Information assembled by HHS shows that, in

Table 1. Text analytes and cutoff concentrations (from Section 3.4 of the Mandatory Guidelines for Federal Workplace Drug Testing Programs Using Urine [1])

Initial test analyte	Initial test cutoff concentration ¹	Confirmatory test analyte	Confirmatory test cutoff concentration
Marijuana metabolites (THCA) ²	50 ng/mL ³	THCA	15 ng/mL
Cocaine metabolite (Benzoylecgonine)	150 ng/mL ³	Benzoylecgonine	100 ng/mL
Codeine/Morphine	2,000 ng/mL	Codeine Morphine	2,000 ng/mL 2,000 ng/mL
Hydrocodone/Hydromorphone	300 ng/mL	Hydrocodone Hydromorphone	100 ng/mL 100 ng/mL
Oxycodone/Oxymorphone	100 ng/mL	Oxycodone Oxymorphone	100 ng/mL 100 ng/mL
6-Acetylmorphine	10 ng/mL	6-Acetylmorphine	10 ng/mL
Phencyclidine	25 ng/mL	Phencyclidine	25 ng/mL
Amphetamine/Methamphetamine	500 ng/mL	Amphetamine Methamphetamine	250 ng/mL 250 ng/mL
MDMA ⁴ /MDA ⁵	500 ng/mL	MDMA MDA	250 ng/mL 250 ng/mL

¹ For grouped analytes (i.e., two or more analytes that are in the same drug class and have the same initial test cutoff):
Immunoassay: The test must be calibrated with one analyte from the group identified as the target analyte. The cross-reactivity of the immunoassay to the other analyte(s) within the group must be 80 percent or greater; if not, separate immunoassays must be used for the analytes within the group.

Alternate technology: Either one analyte or all analytes from the group must be used for calibration, depending on the technology. At least one analyte within the group must have a concentration equal to or greater than the initial test cutoff or, alternatively, the sum of the analytes present (i.e., equal to or greater than the laboratory’s validated limit of quantification) must be equal to or greater than the initial test cutoff.

² An immunoassay must be calibrated with the target analyte, Δ-9-tetrahydrocannabinol-9-carboxylic acid (THCA).

³ *Alternate technology (THCA and benzoylecgonine):* The confirmatory test cutoff must be used for an alternate technology initial test that is specific for the target analyte (i.e., 15 ng/mL for THCA, 100 ng/mL for benzoylecgonine).

⁴ Methylenedioxyamphetamine (MDMA).

⁵ Methylenedioxyamphetamine (MDA).

2015, 12.5 million people misused prescription opioids, 2 million people had prescription opioid use disorder, and 15,281 deaths were attributed to overdosing on commonly prescribed opioids [6]. The economic cost of the opioid epidemic was estimated as \$78.5 billion, based on 2013 data. HHS strongly recommended that all federal agencies implement testing for these opioids on October 1, 2017.

In the 2010 HHS Guidelines, HHS added methylenedioxymethamphetamine (MDMA) as an initial test analyte, with MDMA, methylenedioxyamphetamine (MDA), and methylenedioxyethylamphetamine (MDEA) as confirmatory test analytes. In the UrMG, HHS included MDA as both an initial test and a confirmatory test analyte. Due to the low incidence of MDEA positives in federal workplace drug testing programs, HHS removed MDEA from the list of drugs authorized for routine testing. Because MDEA is a Schedule I drug, a federal agency may still test postaccident or reasonable suspicion specimens for MDEA on a case-by-case basis, or may request a waiver from HHS to test all specimens for this drug.

pH Cutoffs — Invalid and Adulterated. HHS requires agencies to test the pH of each urine specimen, to identify those specimens that are invalid for testing or are adulterated. The criteria address specimens with abnormally low or high pH. HHS raised the lower pH cutoff for adulteration from 3.0 to 4.0. As stated in the preamble to the proposed and final UrMG, the reason for this change was that “the physiologically minimum achievable urine pH that can be produced by the kidneys is about pH 4.5.” HHS also noted that the Department was unaware of any medical conditions or medications that would cause urine pH to be less than 4.5. The adulteration-cutoff change necessitated raising the lower pH range for an invalid specimen from “equal to or greater than 3 and less than 4.5” to “equal to or greater than 4 and less than 4.5.”

Medical Review Officer Requalification. MRO review of laboratory-reported results is an essential element of federal workplace drug testing programs. Only licensed physicians who meet HHS requirements, including specific training and a passing score on an HHS-approved examination, are allowed to serve as MROs for federal agencies. In the UrMG, HHS added requirements for MROs to complete requalification training and pass a requalification examination at least every five years after initial certification. In addition, certified MROs must complete training by an HHS-approved certification entity on any revisions to the HHS Guidelines prior to their effective date, to continue serving as an MRO for federal agency specimens.

Authorized Specimen Types. Some revisions to the previous HHS Guidelines will allow for the use of specimen types other than urine in the future. For example, some UrMG sections refer to collections of an alternative specimen type “as authorized by the federal agency” or to “another authorized specimen type (e.g., oral fluid).” All UrMG references to other specimen types will become effective only when HHS issues final HHS Guidelines for another specimen type. As noted above, urine remains the only specimen authorized for use in federal agency workplace programs at this time.

Additional Information. SAMHSA provides additional information on Drug-Free Workplace Programs and the HHS Guidelines on its website, <https://www.samhsa.gov/workplace>. Resources include the *HHS Urine Specimen Collection Handbook for Federal Agency Workplace Drug Testing Programs* and the *HHS Medical Review Officer Guidance Manual for Federal Workplace Drug Testing Programs*, both of which have been updated to reflect the HHS Guidelines changes effective October 1, 2017. The SAMHSA website also includes a link to a proof of the 2017 Federal Custody and Control Form (CCF) and to the guidance for using the form. Information on the NLCP is also available on the SAMHSA website or from the NLCP contractor, RTI International, by E-mail (nlcp@rti.org) or phone (919 541-7242).

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Upcoming Events

2018 Impression, Pattern and Trace Evidence Symposium

Jan. 22–25, 2018; Renaissance Arlington Capital View Hotel
Arlington, VA, US

HTC-15: 15th International Symposium on Hyphenated Techniques in Chromatography and Separation Technology

Jan. 24–26, 2018; City Hall
Cardiff, UK

American Academy of Forensic Sciences — 70th Annual Meeting

Feb. 19–24, 2018; Washington State Convention Center
Seattle, WA, US

PITTCON Conference and Expo

Feb. 26–March 1, 2018; Orange County Convention Center
Orlando, FL, US

Emirates International Forensic Conference & Exhibition

March 19–21, 2018; Dubai International
Convention & Exhibition Centre
Dubai, UAE

International Association for Chemical Testing — 31st Annual Meeting

April 29–May 4, 2018; Hyatt Regency
Indianapolis, IN, US

American Society of Crime Laboratory Directors — Annual Symposium

May 20–24, 2018; Atlanta Marriott Marquis
Atlanta, GA, US

California Association of Toxicologists — 2018 Spring Meeting

May 7–8, 2018; Venue to be announced
Rohnert Park, CA, US

Mid-Atlantic Association of Forensic Scientists — Annual Meeting

May 15–18, 2018; Delta by Marriott
Hunt Valley, MD, US

The Association of Firearm and Tool Mark Examiners — 49th Annual Meeting

June 3–8, 2018; Charleston Marriott Town Center
Charleston, WV, US

IWBF 2018: 6th International Workshop on Biometrics and Forensics

June 6–7, 2018; Università degli Studi di Sassari
Sassari, Italy

ICFS 2018: 20th International Conference on Forensic Sciences

June 28–29, 2018; Holiday Inn London — Wembley
London, UK

WCABC-2018: World Conference on Analytical & Bioanalytical Chemistry

July 23–24, 2018; Alimara Barcelona Hotel
Barcelona, Spain

International Association for Identification — 2018 International Educational Conference

July 29–Aug. 4, 2018; Henry B. Gonzalez Convention Center
San Antonio, TX, US

TIAFT 2018: 56th Annual Meeting of the International Association of Forensic Toxicologists

Aug. 26–30, 2018; Ghent International Convention Center
Ghent, Belgium

ICFS 2018: 20th International Conference on Forensic Sciences

Aug. 27–28, 2018; Holiday Inn Paris Montparnasse
Paris, France

Australian & New Zealand Forensic Science Society — 24th International Symposium on the Forensic Sciences

Sept. 9–13, 2018; Perth Convention and Exhibition Centre
Perth, Australia

Midwestern Association of Forensic Scientists — Annual Meeting

Sept. 17–21, 2018; Crowne Plaza Hotel — Union Station
Indianapolis, IN, US

Northwest Association of Forensic Scientists — Annual Meeting

Sept. 17–21, 2018; Red Lion Hotel Boise Downtowner
Boise, ID, US

ISHI 2018: 29th International Symposium on Human Identification

Sept. 24–27, 2018; Phoenix Convention Center
Phoenix, AZ, US

Society of Forensic Toxicologists — Annual Meeting

Oct. 7–12, 2018; Hyatt Regency Minneapolis
Minneapolis, MN, US

Northeastern Association of Forensic Scientists — Annual Meeting

Oct. 23–27, 2018; Sagamore Resort on Lake George
Bolton Landing, NY, US

2018 International Conference on Forensic Nursing Science and Practice

Oct. 24–27, 2018; Peppermill Resort Hotel Reno
Reno, NV, US

ADVANCING THE PRACTICE OF FORENSIC SCIENCE IN THE US — UPDATE

The National Institute of Standards and Technology (NIST) is an agency of the US Department of Commerce that works to advance measurement science, standards, and technology in ways that enhance economic security and improve quality of life. NIST conducts scientific research in several forensic disciplines, including DNA, ballistics, fingerprint analysis, trace evidence, and digital evidence. NIST also provides physical reference standards and reference data that forensic laboratories use to validate their analytical methods and ensure accurate test results. In addition, NIST administers the Organization of Scientific Area Committees for Forensic Science (OSAC), which facilitates the development of science-based standards and guidelines for a broad array of forensic disciplines.

The Forensic Technology Center of Excellence (FTCoE), a program of the National Institute of Justice (NIJ), Office of Justice Programs, US Department of Justice, serves as an authoritative resource for both practitioners and developers in their technology areas of focus. RTI International leads a consortium of partners and collaborations including academic institutions, forensic professionals, and forensic laboratories. It assists in the transition of forensic technology from applied research into practice. The goals of the FTCoE are to determine technology needs; develop technology program plans to address those needs; provide solutions; demonstrate, test, evaluate, and transition potential solutions into practice; develop and update technology guidelines; and conduct knowledge transfer and outreach.

Progress made by NIST has been continuously reported in the “Professional Review and Commentary” section of Forensic Science Review (FSR) beginning in January 2014 (Issue 1, Vol. 27). FSR has also been continuously reporting FTCoE’s efforts starting in July 2014 (Issue 2, Vol. 27). The Latest instances of progress made by these agencies are reported in this issue.

National Institute of Standards and Technology Forensic Science Updates

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NIST Upgrades Widely Used Database of Molecular “Fingerprints”

When scientists need to identify an unknown compound, they do what a police detective might do. They get fingerprints — in this case, the “molecular fingerprints” of the unknown compound — and run them through a database of fingerprints from known suspects to look for a match. One of the world’s largest and most widely used databases of molecular fingerprints is the *NIST Mass Spectral Library*, and that library just got larger still. On June 6, 2017, NIST added fingerprints from more than 25,000 compounds to the library, bringing the total number to more than 265,000. This library contains fingerprints of organic compounds — a class of carbon-containing molecules that exist in an endless variety, both natural and manmade.

“This library is used by scientists and engineers in virtually every industry,” said Stephen Stein, the NIST chemist who oversees the *Mass Spectral Library*. He rattled

off just a few uses: diagnosing medical conditions, conducting forensic investigations, identifying environmental pollutants, and developing new fuels. “And anything having to do with food,” he said, since the taste of a food is determined by the complex mixture of organic molecules within it. “The flavor and fragrance industries live and die by this stuff.” To generate the molecular fingerprint of an organic compound, scientists put a sample of the compound into a mass spectrometer. In the most common practice, that instrument heats the sample to vaporize it, then shoots it with a beam of high-energy electrons. That causes the molecules to break into electrically charged fragments, which the instrument separates based on their weight, or mass. When you line up the fragments in order of their mass-to-charge ratio, you get the molecule’s distinctive “mass spectra,” which looks like a barcode and functions like a fingerprint.

The number of organic compounds in the world is astronomical, and any database can only hope to capture a tiny fraction of them. So Stein and his colleagues have to focus on the compounds they think are most important. Among the important compounds whose fingerprints are included in this upgrade are many dangerous drugs. These include dozens of synthetic cannabinoids — aka “synthetic marijuana” — which can cause psychotic episodes, seizures, and death. Also included are more than 30 types of fentanyl, the synthetic opioid that is driving an epidemic of overdoses across the US. Having the fingerprints of these compounds in the Mass Spectral Library will help

law enforcement and public health officials fight the spread of these new and dangerous substances.

The *NIST Mass Spectral Library* is actually several libraries, each covering a variation of the basic analytical method. The library that covers tandem mass spectrometry has expanded by more than 65% the number of compounds covered. For more information on the various libraries and software tools, check out NIST's Mass Spectrometry Data Center. NIST has been publishing its *Mass Spectral Library* since 1989. To ensure that the data in that library is accurate, NIST scientists apply a very high level of quality control. "It's a very specialized activity, and nobody else does it at the level and scale we do," Stein said.

NIST has released the latest version of the *Mass Spectral Library*, and the software needed to run it, to more than 60 distributors that bundle the data and software into mass spectrometry instruments. Owners of existing instruments can also download the latest version from distributors online.

Scientists Automate Key Step in Forensic Fingerprint Analysis

The first big case involving fingerprint evidence in the US was the murder trial of Thomas Jennings in Chicago in 1911. Jennings had broken into a home in the middle of the night and, when discovered by the homeowner, shot the man dead. He was convicted based on fingerprints left at the crime scene, and for most of the next century, fingerprints were considered, both in the courts and in the public imagination, to be all but infallible as a method of identification.

More recently, however, research has shown that fingerprint examination can produce erroneous results. For instance, a 2009 report from the National Academy of Sciences found that results "are not necessarily repeatable from examiner to examiner," and that even experienced examiners might disagree with their own past conclusions when they reexamine the same prints at a later date. These situations can lead to innocent people being wrongly accused and criminals remaining free to commit more crimes. But scientists have been working to reduce the opportunities for human error. Now scientists from NIST and Michigan State University report that they have developed an algorithm that automates a key step in the fingerprint analysis process. Their research has been published in *IEEE Transactions on Information Forensics and Security* (Chugh T, Cao K, Zhou J, Tabassi E, Jain AK: Latent fingerprint value prediction: Crowd-based learning; 13:20; 2018).

"We know that when humans analyze a crime-scene fingerprint, the process is inherently subjective," said Elham Tabassi, a computer engineer at NIST and a co-author of the

study. "By reducing the human subjectivity, we can make fingerprint analysis more reliable and more efficient."

A Key Decision Point. If all fingerprints were high-quality, matching them would be a breeze. For instance, computers can easily match two sets of rolled prints — those that are collected under controlled conditions, as when you roll all 10 fingers onto a fingerprint card or scanner.

"But at a crime scene, there's no one directing the perpetrator on how to leave good prints," said Anil Jain, a computer scientist at Michigan State University and a co-author of the study. As a result, fingerprints left at a crime scene — so-called latent prints — are often partial, distorted, and smudged. Also, if the print is left on something with a confusing background pattern such as paper currency, it may be difficult to separate the print from the background. That's why, when an examiner receives latent prints from a crime scene, their first step is to judge how much useful information they contain.

"This first step is standard practice in the forensic community," said Jain. "This is the step we automated." Following that step, if the print contains sufficient usable information, it can be submitted to the Automated Fingerprint Identification System (AFIS). After AFIS searches its database and returns a list of potential matches, the examiner evaluates them to look for a conclusive match. But the initial decision on fingerprint quality is critical. "If you submit a print to AFIS that does not have sufficient information, you're more likely to get erroneous matches," Tabassi said. On the other hand, "If you don't submit a print that actually does have sufficient information, the perpetrator gets off the hook."

Currently, the process of judging print quality is subjective, and different examiners come to different conclusions. Automating that step makes the results consistent. "That means we will be able to study the errors and find ways to fix them over time," Tabassi said. Automating this step also will allow fingerprint examiners to process evidence more efficiently. That will allow them to reduce backlogs, solve crimes more quickly, and spend more time on challenging prints that require more work.

Training the Algorithm. The researchers used machine learning to build their algorithm. Unlike traditional programming in which you write out explicit instructions for a computer to follow, in machine learning, you train the computer to recognize patterns by showing it examples. To get training examples, the researchers had 31 fingerprint experts analyze 100 latent prints each, scoring the quality of each on a scale of 1 to 5. Those prints and their scores were used to train the algorithm to determine how much information a latent print contains.

After training was complete, researchers tested the performance of the algorithm by having it score a new series of latent prints. They then submitted those scored prints to AFIS software connected to a database of over 250,000 rolled prints. All the latent prints had a match in that database, and they asked AFIS to find it.

This testing scenario was different from real casework, because in this test, the researchers knew the correct match for each latent print. If the scoring algorithm worked correctly, then the ability of AFIS to find that correct match should correlate with the quality score. In other words, prints scored as low-quality should be more likely to produce erroneous results (which is why it's so important to not inadvertently submit low-quality prints to AFIS in real casework) and prints scored as high-quality should be more likely to produce the correct match. Based on this metric, the scoring algorithm performed slightly better than the average of the human examiners involved in the study.

What made this breakthrough possible, besides recent advances in machine learning and computer vision, was the availability of a large dataset of latent prints. Machine learning algorithms need large datasets for training and testing, and until now, large datasets of latent fingerprints have not been available to researchers, largely due to privacy concerns. In this case, the Michigan State Police provided the researchers with the testing dataset, after having first stripped the data of all identifying information.

The next step for the researchers is to use an even larger dataset. This will allow them to improve the algorithm's performance and more accurately measure its error rate. "We've run our algorithm against a database of 250,000 prints, but we need to run it against millions," Tabassi said. "An algorithm like this has to be extremely reliable, because lives and liberty are at stake."

NIST Researchers Lay the Groundwork for a Reliable Marijuana Breathalyzer

Marijuana is now legal for recreational or medicinal use in at least 28 US states and the District of Columbia. But driving under the influence of marijuana is illegal no matter which state you're in. To enforce the law, authorities need a simple, rigorous roadside test for marijuana intoxication. Although several companies are working to develop marijuana breathalyzers, testing a person's breath for marijuana-derived compounds is far more complicated than testing for alcohol. But NIST scientists have taken an important step toward that goal by measuring a fundamental physical property of the main psychoactive compound in marijuana, delta-9 tetrahydrocannabinol (THC). Specifically, they measured the vapor pressure of this compound—a measurement that,

due to the compound's chemical structure, is very difficult and has not been accomplished before. The results were published in *Forensic Chemistry* (Lovestead TM, Bruno TJ: Determination of cannabinoid vapor pressures to aid in vapor phase detection of intoxication; 5:79; 2017).

"Vapor pressure describes how a compound behaves when it transitions from a liquid to a gas," said Tara Lovestead, a NIST chemical engineer and the lead author of the study. "That's what happens in your lungs when a molecule leaves the blood to be exhaled in your breath. So if you want to accurately measure blood levels based on breath, you need to know the vapor pressure." Law enforcement agencies are interested in a breathalyzer because roadside collection of blood or urine would be impractical and invasive. Lovestead is not designing a breathalyzer herself. Rather, by measuring this fundamental physical property, she and her colleagues are laying the technical groundwork for manufacturers to develop accurate devices. Although this research is an important step forward, more research will still be needed to understand how breath levels of THC correlate with blood levels, and what blood levels of THC indicate that a person is too impaired to drive.

What Is Vapor Pressure? Vapor pressure tells you how adventurous a molecule is. Even when they are in solid or liquid form, molecules are in a constant state of jiggly motion, and some will escape as a gas. Molecules with a high vapor pressure, such as ethyl alcohol, are constantly escaping. That's why when you open a bottle of whiskey, you can instantly smell the alcohol molecules that have collected in the air space beneath the cap.

Ethyl alcohol escapes so easily because it is a small molecule with a simple shape. But THC molecules are large and complex, with loops and spurs that cause them to stick together. This results in a very low vapor pressure—so low that you can't measure it the usual way, which would involve putting THC in a closed container and waiting for the pressure to equalize. "You'd be waiting a very long time," Lovestead said.

A New Technique. The researchers overcame that obstacle by using a technology called PLOT-cryo, short for porous layer open tubular cryogenic adsorption. "PLOT-cryo is an extremely sensitive technique for capturing and analyzing things in the vapor phase," said Tom Bruno, a NIST research chemist and co-author of the study. "It was a natural candidate for this type of problem." Bruno invented PLOT-cryo in 2009 for use with airport puffer machines that blow air onto passengers or luggage, then sniff the air for traces of explosives. At the time, existing technology could detect the explosive traces in the air,

but could not precisely identify which compounds were present. PLOT-cryo solved that problem. The technology has since been used to sniff fire debris for evidence of arson and to find clandestine graves by following the faintest scent of decomposition.

PLOT-cryo is so sensitive that it can capture and analyze even the relatively few molecules of THC that escape into the vapor phase. In this experiment, the researchers used pure THC, purchased in compliance with a DEA research license. They swept an inert gas across the sample to capture escaping molecules, then chilled the gas to collect them. By measuring the mass of the recovered molecules in a known volume and temperature of sweep gas, the researchers calculated the vapor pressure. The researchers also calculated the vapor pressure of a second compound, cannabidiol, which is considered less psychoactive than THC.

Measurements Are Fundamental. When it comes to alcohol breathalyzers, NIST helps ensure accurate results by manufacturing ampoules of ethyl alcohol mixed to extremely precise concentrations. Police agencies use these as reference standards to calibrate their breathalyzers. This ensures that different devices used in different jurisdictions produce consistent results — something that’s particularly important when guilt or innocence hangs in the balance. Similarly, accurate vapor pressure measurements for THC will help ensure that marijuana breathalyzers are calibrated to a consistent standard. “Fundamental measurements are the basis of standardization,” Bruno said. “We’re laying the foundation for the reliable systems of the future.”

Speaking of Error in Forensic Science: *The International Forensic Science Error Management Symposium at NIST*

When Continental flight 3407 crashed on approach to Buffalo Niagara International Airport on February 12, 2009, all 49 persons on board, and one on the ground, were killed. The National Transportation Safety Board began its investigation within hours, and ultimately determined that the crash was caused in part by pilot error, with fatigue as a contributing factor. To prevent similar accidents from happening in the future, the Federal Aviation Administration issued new work rules mandating shorter shifts and longer rest periods for all commercial pilots.

The aviation industry is well known for its approach to managing errors, which involves investigating root causes and establishing new practices to address them. Many other industries, such as health care and energy, have emulated this approach. But the forensic science industry has been slow to adopt a proactive approach to error management, despite the fact that in the courtroom,

as much as in the air or on the operating table, lives are often at stake. But some forensic scientists are working to modernize the industry’s approach to managing error, and many of them were present at the *International Forensic Science Error Management Symposium*, held last month at NIST.

This is the only widely attended conference in the US dedicated to managing forensic science errors. In recent years, high-visibility errors have occurred at crime labs in almost every state. These have ranged from simple mistakes, such as mislabeling evidence, to testimony that overstates the scientific evidence, to criminal acts. The latter category includes dry-labbing, which is when an examiner fraudulently claims to have performed laboratory analyses that in fact were never done. Dry-labbing is not an error, it’s a crime, but if it goes undiscovered, there is a problem with error management. The cost of these cases, whether the result of simple mistakes or criminal malfeasance, have been incalculable. Innocent people have spent years behind bars, countless criminal cases have been thrown out due to tainted evidence, and the cost of litigation has soared.

So why has the forensic science industry been slower than other industries to adopt best practices for managing errors? Lynn Garcia, general counsel for the Texas Forensic Science Commission, addressed this question during her plenary presentation. Hospitals and airlines have very high-stress work environments, she said, but they are not, by design, part of an adversarial system. Forensic science, because of its role in the courtroom, is. When an error is discovered, defense lawyers and prosecutors may exploit them, or minimize them, to advance their case. “That culture of fighting and not giving an inch, of trying to discredit people, makes it really hard to do the proactive work that’s needed to advance and improve forensic science,” Garcia said. When it comes to responding to error, she urged the forensic and legal communities to focus on accountability rather than blame.

Focusing on accountability requires transparency, said conference organizer Mark Stolorow, who as director of OSAC leads NIST’s effort to promote standards and best practices for the industry. “You cannot get to the root cause of an error without transparency and full disclosure,” he said. Transparency was a theme that came up repeatedly at the conference. During his presentation, Peter Stout, CEO and president of the Houston Forensic Science Center, showed a section of his agency’s website where the public can search for online reports of all quality incidents and corrective actions that occur under his watch. Transparency, he said, “has made an enormous difference in regaining the public’s trust.” It also puts the focus where it belongs — not on individual evidence examiners, but on the entire system, including a laboratory’s quality control infrastructure.

Focusing on accountability also requires a venue where forensic experts can openly discuss errors and lessons learned. That's one way that NIST was able to make a valuable contribution. NIST is leading an effort to strengthen forensic science, but it is not a regulatory agency, and it is not involved in actual casework. Because of that, NIST is able to provide a neutral ground where stakeholders can have a conversation about error that one attendee described as, until recently, "taboo". Judging by the frank presentations at this conference, that conversation is well underway. Video of the speakers' presentations can be viewed and downloaded from the Symposium page at the NIST website.

Forensic Technology Center of Excellence

Forensic Technology Center of Excellence: Informing the Advancement of Emerging Technologies — 2017 Year-End Update —

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Conferences, Meetings, and Symposia

STEM Industry Summit. **STEM in the Park** is a science, technology, engineering, and math (STEM) mentoring program sponsored by the Research Triangle Foundation that facilitates interactive mentorships for K-16 students in Durham and Wake counties of North Carolina. On June 9, 2017, STEM in the Park hosted the first annual STEM Industry Summit at the Frontier, an innovation hub in the heart of Research Triangle Park. More than 45 people from 23 STEM-related companies around the triangle attended the summit and shared their experiences with STEM outreach initiatives. Three FTCoE staff members participated in the summit, and learned about STEM outreach in the community and how to effectively transfer their knowledge of forensic science to students and young professionals. Providing knowledge transfer to students and young professionals supports the values and mission of the FTCoE into the future.

Opioid Misuse and Overdose Prevention Summit.

The Opioid Misuse and Overdose Prevention Summit, sponsored by the North Carolina Department of Health and Human Services, was held June 27–28 in Raleigh, NC. The summit addressed opioid misuse, addiction, and overdose, and featured presentations from national, state,

and local leaders on innovative policies, prevention efforts, social determinants, and several other topics pertaining to the opioid crisis. Dr. Jeri Roper-Miller of the FTCoE attended the summit to strengthen the FTCoE's presence in efforts that aim to address the opioid epidemic in the US, and solicit feedback regarding topics to address in future FTCoE activities.

International Association for Identification Conference.

The annual *International Association for Identification (IAI) Forensic Educational Conference* was held August 6–12 in Atlanta, GA. The IAI is the oldest and largest forensic professional organization in the world, and the IAI Conference is the leading educational experience for forensic physical evidence professionals. The FTCoE participated in the conference in a variety of ways, including booth operation, outreach, and dissemination. Additionally, Heidi Eldridge, a research scientist who supports the FTCoE, presented on "One Man's Trash: A White-Box Study into the Factors Driving Latent Print Suitability Decisions" and led a workshop on latent print testimony. The workshop considered some of the challenging concepts that are encountered in court, including error rate, discriminability, certainty, variability, bias, uniqueness, and the identification decision.

Rapid DNA Technology Forum.

The FTCoE hosted the *Rapid DNA Technology Forum* August 15–17 in Alexandria, VA. Rapid DNA technology has quickly advanced over the past several years with two commercially available systems being adapted to analyze the Combined DNA Index System (CODIS) panel, as



Figure 1. Rapid DNA Technology Forum logo.

well as the Rapid DNA Act of 2017 becoming law on August 18. This forum provided more than 130 attendees, from the forensic DNA community, opportunities to be updated on commercially available Rapid DNA technologies, to hear lessons learned from several early adopters spanning local law enforcement and federal agencies, and to discuss moving forward as a community. The attendees included representatives from several government organizations including the Federal Bureau of Investigation (FBI), NIJ, NIST, and the Department of Homeland Security (DHS), as well as the American Society of Crime Laboratory Directors (ASCLD), practitioners, and vendors. Senator Orrin Hatch, co-author of the recently passed Rapid DNA Act, also offered his thanks to the community in attendance of the forum through a welcome letter featured in the forum's program, in which he mentioned that he, "stand[s] ready to continue our work together as we seek

to improve DNA analysis and make our criminal justice system more efficient and effective.”

Human Factors Sourcebook Working Group. The FTCoE hosted a two-day working group meeting August 17–18 in support of the Human Factors in Forensic Science Sourcebook project at RTI International. The goal of this sourcebook is to find areas in which human factors knowledge can be used to improve laboratory practice and to bridge the gap between existing knowledge and operational implementation. Working group members, both academic and practitioner, had productive discussion about the chapter content and flow, and brainstormed examples and ideas for inclusion. A second working group meeting will convene in March 2018 to discuss chapter drafts.

Online Webinars and Workshops

Webinar Series: Opioid Crisis — A Public Health Enemy. Rates of opioid use and misuse have reached epidemic proportions and are affecting many aspects of both criminal justice and forensic sciences programs. Opioid addiction is the driving force behind this increase in use. In 2015, nearly 3 million Americans reported a substance use disorder related to prescription pain relievers or heroin, fueling a steady increase in fatalities to an estimated 91 US deaths daily. Far from slowing, these rates are doubling, quadrupling, or increasing even more alarmingly in some areas. Law enforcement, medical professionals, laboratories, and legal agencies are facing unmanageable caseloads, budget shortfalls, and other challenges in achieving safety, analytical preparedness, and basic education/training. Reliable surveillance and intelligence are needed more than ever to combat the fast-paced life cycles of emerging drugs. The legislative quagmire is just as burdensome, as policy change cannot happen without data to support it.

This webinar series offers a multifaceted perspective on how diverse criminal justice disciplines are addressing these challenges, sharing their knowledge, and advancing science, technology, and law. Dealing with the impacts of the opioid crisis to the criminal justice system requires better reporting, surveillance, research, technology, and policy than are currently in force. The FTCoE has hosted eight webinars that are part of the opioid crisis webinar series, which will continue into 2018:

- Identify Synthetic Opioids Using Ambient Ionization TOF-MS;
- Opioids and the Drain on Laboratory Resources;
- Fentalogs: Pharmacology, Toxicology, and Analytical Approaches;
- Opioid Substances: A Threat to Animal Welfare and Safety;

- Dreamland: Sam Quinones Explores America's Opiate Epidemic;
- Opioids and Death Investigation: A “Perfect Storm”;
- Making the Case for Prevention: Fighting the Opioid Epidemic; and
- Strategies and Considerations for Trace Detection of Fentalogs.

Webinar Series: Forensic DNA—The Beginning of the SNP Era. The field of forensics is constantly evolving. While short tandem repeats (STRs) are currently used in all forensic DNA laboratories for human identification, single nucleotide polymorphisms (SNPs) have emerged as new markers of interest. These new markers present several benefits, including the ability to analyze smaller DNA fragments, the ancestral and phenotypic information they may carry, and the ability to distinguish STRs of the same size. New technologies for genotyping SNPs have been developed in recent years, and they will continue to advance for many years to come.

This webinar series explores the use of SNPs for forensic applications and discusses recent advances in the field. The FTCoE is collaborating with George Washington University, alongside Dr. Daniele Podini, to deliver this webinar series. The FTCoE hosted three extended webinars for this series, which will continue into 2018:

- Record Linkage of CODIS Profiles with SNP Genotypes;
- Predict Human Appearance from DNA Focusing on Pigmentation; and
- The Evolution of SNPs as a Forensic Marker.

Bloodstain Pattern Analysis Technology Transition Workshop. In collaboration with Dr. Stephen Michielsen of North Carolina State University (NCSU), the FTCoE hosted the *Bloodstain Pattern Analysis on Textiles Technology Transition Workshop* at NCSU on October 11–13. Every year, millions of items of bloodstained clothing and other textiles are being examined in forensic laboratories around the world, yet there is, to date, no standard or well-documented method for analyzing small bloodstains on these textiles. This is due in part to the great variety and complexity of textiles, which can deform easily, but may also contain critical information about a bloodshed event. In this three-day, hands-on workshop, participants explored key properties of textiles that dictate how they interact with blood, how their manufacture alters these properties, how small bloodstains develop on textile substrates, and how blood transfers from one surface to another. A total of 28 individuals attended the workshop. Of the 28 attendees, 26 were forensic science practitioners and 2 were retired police officers who currently teach bloodstain pattern analysis courses to practitioners.



Figure 2. Bloodstain Pattern Analysis Technology Transition Workshop.

Podcasts

Beginning in May 2017, RTI International's Center for Forensic Science launched "Just Science", a podcast for forensic science professionals and anyone with an interest in learning more about how real crime laboratories are working to do their job better, produce more accurate results, become more efficient, and solve more crimes. This podcast explores a range of issues, including leadership in the crime lab, new technologies, sexual assault response, and broader challenges for science and public security. Every forensic discipline is discussed, including DNA, fingerprints, trace evidence, toxicology, controlled substances, and crime scene investigation. The FTCoE has hosted a total of 23 episodes, over two complete seasons, and one special release season recorded at the NIJ's R&D Symposium held at the American Academy of Forensic Science. The podcasts can be played on iTunes, Google Play, Stitcher, and Soundcloud. The following episodes have had a total of 8,173 plays.



Figure 3. Just Science Podcast logo.

Technical Notes

Evaluation of Existing Technologies for Novel Analysis and Probabilistic Interpretation of Organic Gunshot Residue. Firearms exposure has traditionally been monitored by screening for the presence of inorganic particles present in gunshot residue (GSR). These inorganic compounds are associated with the primer in ammunition. Recent research efforts have explored alternative approaches for monitoring firearms exposure that screen for the presence of organic GSR (OGSR) components, which come from propellants and stabilizers. Through the FTCoE, scientists at West Virginia University (WVU) evaluated novel adaptations to two existing technologies for their suitability as screening methods for OGSR. The

resulting technical note is a continuation of the OGSR evaluation, "Organic Gunshot Residue Analysis for Potential Shooter Determination" by WVU, first reported by the FTCoE in May 2015. The methods evaluated in the technical note include ion mobility spectrometry and inlet thermal desorption gas chromatography mass spectrometry. The 2015 report and this technical note can be found on the FTCoE website, <https://www.rti.org/impact/forensic-technology-center-excellence-ftcoe>.

Detection of Organic Gunshot Residue Using Capillary Microextraction of Volatiles with Cryofocusing.

Through the FTCoE, scientists at Florida International University's (FIU's) International Forensic Research Institute evaluated the capability of capillary microextraction of volatiles (CMV) to extract the volatile organic compounds (VOCs) that constitute organic gunshot residue (OGSR) on the hands of shooters. The team at FIU worked to optimize a field sampling method for the detection of OGSR and designed a custom-built Peltier cooling device for CMV to assess whether cryofocusing during the extraction process could improve the detection of OGSR in real-world samples. The benefits of cryofocusing, which were demonstrated in this work for the improved extraction of volatiles from OGSR, may be extended to other important areas of forensic chemistry, such as fire debris analysis and headspace signature analysis of drugs of abuse.

Sexual Assault Initiatives

The Multidisciplinary Sexual Assault Glossary. The Center for Nursing Excellence International (CFNEI), in collaboration with the FTCoE, has developed a sexual assault online glossary for medical, law enforcement, and legal professionals. Effective communication among interdisciplinary professionals is essential. To develop this glossary, CFNEI engaged with multidisciplinary subject matter experts who contributed to developing the terms list, writing associated definitions, and reviewing the multidisciplinary terminology/definitions. A consensus model was used to clarify ambiguous terms or terms with opposing definitions found in the literature and/or reference materials. This project served to create a resource that can be used to help bridge language-related communication gaps and potential miscommunications associated with discipline-specific terminology. This glossary was initially developed in 2016 under award number 2011-DN-BX-K564, which led to over 970 terms being uploaded to the searchable glossary. Under the current award, additional terms have been added and the glossary now hosts 2,995 unique terms. This glossary is currently available at www.cfnei.com and www.forensicCOE.org.

**TEITELBAUM'S COLUMN ON FORENSIC SCIENCE
— HISTORICAL PERSPECTIVE —**

**The First Criminal Conviction Based on
Fingerprint Evidence: Argentina, 1892**

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Although history largely credits Europeans for the invention of fingerprint identification systems (primarily William Herschel, Edward Henry, Francis Galton, and Henry Faulds), a Croatian man who emigrated to Argentina created, in the view of many experts, a far superior fingerprint system and used his system to convict a murderer in the first recorded use of fingerprints in a criminal case. This conviction occurred in 1892, a full 10 years before fingerprints figured in criminal cases in England and Paris.

On June 19, 1892, in Necochea, a small town on the Argentinian coast, a 26-year-old woman named Francesca Rojas ran out of her hut screaming "He killed my children!" Inside the hut, her children, boys aged 4 and 6, were found in their bed with their heads smashed in. Rojas, her neck bleeding from a wound, accused a man named Pedro Velasquez of murdering her children because she refused to marry him. She claimed that when she had returned home from work, he had been inside her hut, had pushed past her as he came running out, and she had found her children dead with their heads crushed.

Juan Vucetich (1858–1925) moved to Argentina in 1884 from his native Croatia and eventually found employment in the Statistical Bureau of the La Plata (part of the Buenos Aires province) police department. The Bertillon criminal identification system was currently in vogue and Vucetich studied the methods of taking measurements, but while doing so, became fascinated with the developing field of fingerprint classification.

Vucetich focused primarily on Francis Galton's fingerprint research but he quickly decided to extend Galton's "single finger" method to include all 10 fingers, as well as ingeniously creating a sophisticated and near-foolproof system of categorizing fingerprint patterns. While his talents were formidable in the field of fingerprint classification, the same perhaps cannot be said for his talents in nomenclature, exemplified in his choice of names for his system: *Incufalangométrico*.

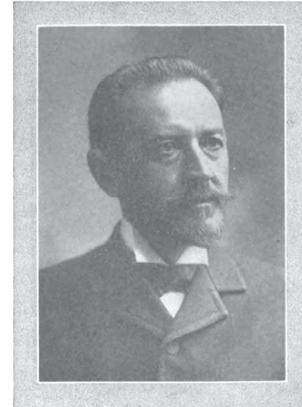


Figure 1. Juan Vucetich (1858–1925).

Velasquez, the man accused by Rojas of murdering her children, was endlessly questioned by the police, and, by some accounts, tortured in order to extract a confession. Some reports even describe how Velasquez was locked overnight in a room with the murdered children, but he continuously maintained his innocence.

A police inspector, Edward Alvarez, was sent from nearby La Plata to investigate the murders. Alvarez had taken an interest in Vucetich's fingerprinting efforts and appreciated the potential utility of the identification system. Once in Necochea, he learned that Velasquez had a credible alibi regarding his whereabouts at the time of the murders. He also learned that Rojas was in love with another man who refused to marry her because of her children. Alvarez focused his attention squarely on Rojas.

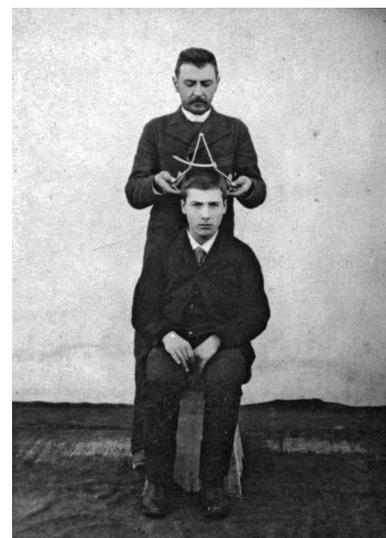


Figure 2. Vucetich taking anthropometric measurements (1893).

With thousands of Argentinians fingerprinted and a working identification system in place, Vucetich officially abandoned the Bertillon measurement system. He wrote the first of three fingerprint instructional manuals, all paid for out of his own pocket, making his case for the superiority of fingerprinting over bertillonage (the colloquial term for Bertillon's system).

Alvarez searched for hours in the hut where Francesca Rojas' children were killed and finally found the imprint of a thumb, made in blood, on the door of the room where the children had slept. He obtained a saw and cut out the section of the door, then had Rojas brought to the police station where he had her thumb inked and pressed onto some paper. Using a magnifying glass, Alvarez compared her print to the bloody print on the door section and, despite his minimal experience working with fingerprints, could instantly see that they matched. When he showed the proof to Rojas, she became hysterical and confessed that she had cut her own neck and killed her children because they had prevented her from marrying the man she loved.



Figure 3. Francisca Rojas fingerprint card.

When Alvarez returned to La Plata with the door section, his story created tremendous excitement within the police department. Vucetich could scarcely believe that his system had worked, and he would see several more cases successfully resolved over the next year utilizing his fingerprint system. The next several years, however, beginning in 1893, were incredibly frustrating for Vucetich. One police chief would order him to shut down his dactyloscopy system and replace it with the Bertillon system (anything coming from Paris, which included Bertillon's measurement system, was greeted with open arms by many Argentinians), while the next chief would reverse the order. By 1901, however, Argentina was the first country in the world to base its identification methods entirely on fingerprinting.

Vucetich would see his own fingerprint system become established throughout most of South America, where it is still used today. China, Japan, and many other non-European countries also adopted Vucetich's system, and even the celebrated French criminologist Edmond Locard considered it to be a near-perfect system. The system became known as Dactiloscopia (Dactyloscopy), or, sometimes, Vucetichismo.



Figure 4. A Dactilonomo, designed by Vucetich to demonstrate fingerprint patterns (1891).

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Sidenote:

There are several accounts of a meeting — the only meeting between Alphonse Bertillon and Juan Vucetich — and it did not go well. The most authoritative account of the meeting, which occurred in 1913, came from Bertillon's niece. Bertillon was suffering from a multitude of health problems and would, in fact, die the following year. In addition to his ill health, he knew that his anthropomorphic system of measurement, his Bertillon System, had fallen into disfavor among criminologists and would possibly not even survive him. And now, the calling card of the visitor waiting to see him read “Juan Vucetich”, the man who had perhaps done more damage to his legacy than anyone else by having publicly denounced Bertillonage. Vucetich had come to pay his respects to Bertillon, but, according to reports, Bertillon let Vucetich wait outside for an inordinate amount of time, and when he finally opened the door to admit him, refused to shake his hand, angrily stated “Sir, you have tried to do me a great deal of harm!” and slammed the door in his face.

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Book Reviews

Forensic DNA Evidence Interpretation, 2nd ed

J. S. Buckleton, J. A. Bright, D. Taylor, Eds
CRC Press: Boca Raton, FL, US; 2016

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The second edition of *Forensic DNA Evidence Interpretation*, edited by John S. Buckleton, Jo-Anne Bright, and Duncan Taylor, provides an extensive reference for analysts performing the complex process of DNA interpretation. As the forensic community confronts DNA interpretation inconsistencies, the timely release of this updated text (originally released in 2005) provides a resource to support the discussions surrounding interpretation procedures. Extensive updates cover interpretation from single-source to complex profiles and an exploration of the continuous model utilized in probabilistic genotyping software. While this book will not quell the debates surrounding interpretation methods, it does provide a foundation to comprehend numerous methods from a theoretical and statistical understanding.

The three editors essentially author each chapter with additional contributions from leading DNA and statistical experts. This continuity in authorship provides a cohesive text and tone that is not always achieved by an edited text. The book begins with a short history of DNA and a refresher on basic biology while describing STR analysis and next-generation sequencing. Chapter one continues by explaining STR profiles and PCR effects that affect interpretation, including stutter, drop-in, and other artifacts. Chapter two explores uncertainty and probability as a framework for evidence interpretation. The chapter provides a full description of different types of probabilities utilized in evidence interpretation. The approaches include frequency in terms of both coincidence probabilities and exclusion probabilities, the likelihood ratio framework, and a full Bayesian approach. There is a nice section in this chapter explaining evidence interpretation in court, which is very practical for DNA analysts. This section also indicates different fallacies and tips for avoiding these fallacies when testifying. Chapter three discusses three population genetic models, the product rule and two variants of subpopulation correction. The next chapter discusses how relatedness affects the interpretation process. Chapter five is dedicated to validating databases to understand where allele frequencies come from. Since this

is written for an international audience from a European perspective, limited mention of CODIS is present in this book, which differs from American authored textbooks. Chapter six discusses the differing opinions regarding the uncertainty of the numerical weight applied to a match.

Essentially chapters one through six provide the foundational information necessary to understand DNA interpretation. The next few chapters explore interpretation of samples beginning with single-source samples from good-quality profiles with low probability of dropout and moving to low-template DNA samples. The book proceeds through the interpretation of complex profiles with descriptions of manual interpretation and semicontinuous methods. The following chapter explains the continuous model by focusing on the STRmix interpretation software. STRmix is the only continuous approach explored, given the editors' familiarity with the program. Although it is generally known that the editors also created the program, this is not explicitly stated, which would have increased transparency. The chapter explains how STRmix works through to its acceptance in court. Later chapters describe nonautosomal markers such as lineage markers and mitochondrial testing and parentage testing. The book concludes with DNA intelligence databases and broadly describes how the databases function.

The introduction of the book states that it is written for caseworkers "less mathematically attuned", but this text relies heavily on presenting the mathematical underpinnings associated with DNA evidence interpretation. The benefit of this textbook is the strong mathematical-focus rather than the purely theoretical. Many formulas are provided for calculating different statistics based on scenarios encountered by DNA casework analysts. This is a comprehensive text for DNA practitioners. Certain content could also be valuable to a master's-level forensic biology student to increase the understanding of DNA statistics prior to entering a laboratory. The extensive reference list provides over 1,000 additional sources, but not all appear to be accessible. The text does provide an international perspective, which is of significant value for US practitioners to better understand methods applied worldwide. This will be increasingly important as the use of likelihood ratios continues to expand in the US given its established use in other countries. The second edition of *Forensic DNA Evidence Interpretation* is an important text for DNA practitioners to better understand the methods that underlie current DNA interpretation methods.

Forensic Uses of Digital Imaging, 2nd ed

J. C. Russ

CRC Press: Boca Raton, FL, US; 2016

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Forensic Uses of Digital Imaging by John C. Russ does an admirable job to further educate the forensic practitioner who possesses a solid understanding of photography. Most of the information is highly technical and the text does a good job of breaking this down to a more readily understandable level, assuming that the reader has some basic photography and imaging experience. It covers a number of topics that are important for a forensic photographer to understand to be truly competent in today's world of complex technology. This covers issues like the size of the chips in digital cameras in relation to 35-mm film and the variation in these chips among the different cameras and manufacturers. Also, topics like file compression, color, resolution, and spectrum range are covered in detail. It should be noted that this reference goes beyond just "basic" photography to include areas such as captured video and microscopic images.

Forensic Uses of Digital Imaging then covers image processing and enhancement. Those who are familiar with George Reis's book *Photoshop CS3 for the Forensic Professional* (Wiley Publishing: Indianapolis, IN, 2007) will find this reference to be a very useful "next step". This book is not the usual "how to" book covering basic steps (as is the case with Reis's). While this book does discuss the basic concepts of enhancement, it also goes well beyond the basics. It covers the processing of video evidence that is not addressed in detail in other reference books. For example, it addresses aspects such as: calibrating, color correction, adjusting contrast/brightness, reducing noise, complex backgrounds, sharpening contrast, and much more. This text then moves on to examine more advanced processing techniques. These are the "evolutional" next steps from the previous section where most of the processes have been known and in use since the early days of Photoshop and image processing. The techniques in this section are those that were not previously possible, but have more recently become more routinely utilized with the development of more powerful computers, processors, and computationally intensive algorithms. This section includes a number of filters for a variety of uses. In addition, it also covers advancements in noise reduction, edge enhancements, 3D imaging, multiple images, and a number of specialized methods. Like the previous section, it is not a step-by-step guide. However, it is an expansive collection of what is possible for image-processing professionals.

In the fourth section, the text covers topics of comparison and measurement. For the forensic professional

these are extremely useful tools that allow for a number of uses in actual processing of collected and processed images. The comparison topics include useful practices such as side-by-side comparison, matching features or dimensions, facial recognition and biometric measurements, foot and tire impressions, and more. Furthermore, it goes into areas like photogrammetry, dimensional measurements, object measurements, size and shape, plus identification uses. There is also a very useful section to help in detecting altered images. This is of interest to most professionals in this area, even if they are not in the business of examining images for prior manipulation.

This book finishes up strongly with the last section dedicated to interpreting and presenting evidence. This covers not just image displays, but also how to explain and show the procedures in legal proceedings. As anyone working in this arena knows, it is imperative for the imaging professional to be able to recreate and show their work in a motions hearing, courtroom, or simply as a pretrial process. The section additionally covers the use of dynamic models discussing how to explain image processing and measurement as well as how to deal with question or issues surrounding Photoshop and similar programs that the jurors may be familiar with. The reviewer found this section a pleasant surprise, covering a topic missing from most forensic and imaging texts. For those working in the criminal justice system, it is extremely important to be able to competently testify at trial. This final section does well to equip you for that often dreaded experience, in both explaining your work as well as handling possible questions or issues that may arise as part of the confrontational process of a trial.

Photography and video have become a regular part of criminal investigations. Rarely is there a case where there is not some sort of photographs or surveillance video. With the vast majority of the public carrying a camera/video recorder on their person as part of their cell phone, more incidents and people are being captured on digital imaging. Pair that with the reduced cost of surveillance systems that previously had been a luxury item, and now surveillance systems are commonplace not only in most businesses open to public access but also in private residential settings.

Regardless of how it comes into forensic case folders, forensic practitioners need to be prepared to deal with digital images. For crime scene photographers, this becomes paramount as they will likely be the ones processing the images. At the very least, crime scene photographers will be the first persons asked by investigating officers if anything can be done with the images or video that was captured during the course of a forensic investigation. This area gets highly technical, and both photographers and imaging practitioners should be prepared to know the benefits and limitations of digital images, and most of all — be familiar with today's technology and equipment and how to best capture evidence through photography.