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TABLE OF CONTENTS

FORENSIC SCIENCE AROUND THE WORLD

Taiwan Academy of Forensic Sciences Opens Multidisciplinary Library 2
TIAFT Delights With "Addictive Days and Toxic Nights" in Ghent 5
International Council on Alcohol, Drugs, and Traffic Safety — 2018 Regional Meeting in Prague 6
Upcoming Events 7

ADVANCING THE PRACTICE OF FORENSIC SCIENCE IN THE US — UPDATES

National Institute of Standards and Technology Forensic Science Updates 8
Forensic Technology Center of Excellence: Updates on Sexual Assault Special Initiative 14

NEW BOOKS AND BOOK REVIEW

New Forensic Science Books 16
Book Review 17

TEITELBAUM'S COLUMN ON FORENSIC SCIENCE — HISTORICAL PERSPECTIVE

Who Made That Ladder? Arthur Koehler and the Lindbergh Kidnapping Case 18

COMMENTARY

"Junk Science" and Reasonable Doubt 20

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).

[a]The 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.

Taiwan Academy of Forensic Sciences Opens Multidisciplinary Library

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Facilitated greatly by Prof. James C.-I Lee's efforts, the forensic science community in Taiwan founded a professional organization, the Taiwan Academy of Forensic Sciences (TAFS; *http://tafs.cid.cpu.edu.tw/english%20version/etafs4.htm*), in 2002 and held its first conference on September 14 of that year. With continuous efforts by former presidents (I-A. Low, M.-H. Lin, H.-H. Meng, and W.-T. Chang) and board members, TAFS has now grown to an organization with 347 active members and it holds annual conferences, often with international components. For example, the 2011 TAFS annual conference included a "Forensic Science & Wildlife Conservation Efforts" component with the participation of a significant number of attendants from the Asia-Pacific region (*http://www.forensicsciencereview.com/2011conference/photo.html*).

Taiwan Academy of Forensic Sciences Library

During the last two years, the TAFS president and board members developed a strategy to expand the forensic science literature base in Taiwan. Since journals are now so widely available on the Internet, focus was placed on the collection of books. With the support of Hao-Ming Lai, formal head of the country's highest judicial institution (Judicial Yuan), this initiative has gained strong momentum and received major grants from several industrial entities (e.g., Aurora Group: Taipei, Taiwan), civil organizations (e.g., Rotary Club of Taipei Yenpin: Taipei, Taiwan), and a significant number of individual contributors. TAFS has now completed its first procurement project of 923 books (in English language) with an estimated value of NT$2,500,702 (approximately US$80,300).

The TAFS library (approximately 86 m^2) is set up on the third floor of the Science Building at the Central Police University (Taoyuan, Taiwan). Books are categorized into the five discipline areas as defined by the National Institute of Standards and Technology (NIST)'s Organization of Scientific Area Committees (OSAC), with the addition of a sixth area, "Others" (**Figure 1**). Equipped with two photocopies donated by the Aurora Group, the TAFS library is open to members of the forensic science community, including TAFS members, faculty of the Central Police University, forensic science practitioners, and judges and prosecutors. The next phase of procurement will include books in Japanese, German, and Chinese languages.

Figure 1. Discipline areas adopted for categorizing the book collection in the library.

An official ribbon-cutting ceremony for the TAFS library was held on September 21, 2018. In the presence of many dignitaries (including all major forensic science laboratory directors in Taiwan, the president of Central Police University, the president of Rotary Club of Taipei Yenpin, and members of the judicial system), Mr. Lai remarked on the effort and process leading to the establishment of the library and highlighted the importance of knowledge in guiding legal proceedings through the course of justice (**Figures 2** and **3**).

Forensic Science in Taiwan

The practice of forensic science and the bureaucratic structure of related agencies in Taiwan are similar to those adopted by most Western countries in the world. Specifically, forensic laboratories — conducting evidence analysis supporting the legal proceedings — are mainly

*Prof. Winston W. T. Chang is the immediate past president of the Taiwan Academy of Forensic Sciences (TAFS), key person for founding the TAFS Library.

Figure 2. Hao-Ming Lai, the formal head of Taiwan's highest judicial institution (Judicial Yuan), delivered an inspiring speech in the library's ribbon-cutting ceremony on September 21, 2018.

affiliated with law enforcement agencies. Funding of these laboratories come from several different branches of the government, including the Ministry of Interior, Ministry of Justice, Ministry of Defense, and Ministry of Health and Welfare. Major laboratories have been accredited under the ISO/IEC 17025 combined with ILAC-G19 quality system.

Crime Laboratory. A crime laboratory (as we call it) is universally set up as a unit in each police department of the 22 administrative divisions (6 municipalities, 13 counties, and 3 provincial cities) under the national government of Taiwan. The size and the function of these crime laboratories vary considerably, ranging from a forensic science center, staffed with 33 forensic scientists and supporting personnel, of Taipei City's police department to <5 staff members in most of the 16 counties and provincial cities. (Logically, the functions of the staff in this latter category of crime laboratories are merely associated with the collection and submission of evidential materials.) These police departments (and accordingly the crime laboratories) are funded by their respective host administrative divisions; however, staffing and operation of these police organizations are centrally controlled by the National Police Administration that reports directly to the central government's Ministry of Interior. This institution (National Police Administration) is also structured with a crime laboratory (Forensic Science Center under its Bureau of Criminal Investigation) that is currently 133-manpower strong and well-equipped with modern instrumentations. The analyses of most crime-related evidential materials (except those derived from fire-related cases) are conducted in this laboratory.

Forensic Science Department in the Ministry of Justice Investigation Bureau. The Ministry of Justice Investigation Bureau (MJIB) is a governmental, judicial, investigation agency that takes the responsibilities of "safeguarding national security; maintaining social stability and protecting the people's well-being". According to Article No. 2 of "The MJIB's Organizational Ordinance", MJIB is responsible for the investigation on violations against national security and interests, and matters concerning internal security. The Forensic Science Department reports directly to the bureau chief and includes chemical analysis, questioned document, physical identification, forensic DNA, and image identification laboratories. These laboratories are responsible for the analysis of evidential materials derived from cases under the jurisdiction of MJIB.

Figure 3. Many dignitaries and members of the Taiwanese forensic science community spoke and listened at the library's ribbon-cutting ceremony.

Institute of Forensic Medicine in the Ministry of Justice. Institute of Forensic Medicine is another forensic institution under the Ministry of Justice. This institution, similar to a major medical examiner's office in the United States, includes pathology, forensic toxicology, and forensic DNA divisions to conduct autopsy and the analysis of postmortem evidence specimens.

Military Police Command's Forensic Science Center. Military Police Command is a separate branch of the nation's armed forces under the Ministry of Defense. Under this Command, the Forensic Science Center is composed of Chemical Forensic, Physical Forensic, and Crime Scene Investigation Divisions to work on cases involving military personnel.

Workplace Drug Testing Laboratories. Currently, there are 14 commercial laboratories authorized to conduct drug analysis of urine specimens submitted through various workplace drug-testing programs. These laboratories are required to maintain a laboratory certification program under the auspices of the Ministry of Health and Welfare's Food and Drug Administration. This program was established in 1998 with the assistance of personnel associated with the US Department of Health and Human Services's National Laboratory Certification Program.

Forensic Science Educational Programs. Central Police University (Taoyuan, Taiwan) — the publisher of *Forensic Science Review* — is a professional educational institution under the Ministry of Interior. In addition to providing training programs to personnel working in the nation's police and fire departments, Central Police University also offers undergraduate and graduate degree programs in several law enforcement-related disciplinary areas. Degrees are granted following the regulations governed by the Ministry of Education and applied to regular universities.

Crime and fire laboratory personnel in the nation are typically graduates of the Department of Forensic Science (*http://efs.cpu.edu.tw/bin/home.php*) and Department of Fire Science (*http://efc.cpu.edu.tw/bin/home.php*) in the Central Police University.

Faculty members in the Department of Forensic Science are responsible for the publication of *Forensic Science Journal* (*http://www.airitilibrary.com/Publication/alPublicationJournal?PublicationID=P20151216002*), an open-access journal of international nature; and the operation of CSI Forensic Science Experience CAMP (*http://fs.cpu.edu.tw/files/14-1081-26294,r149-1.php?Lang=zh-tw*), a semiannual event instigated in 2015 to promote forensic science among high school students.

Graduate Institute of Forensic Medicine in the College of Medicine, National Taiwan University (Taipei, Taiwan), is another institution that conducts research and provides education programs in the fields of forensic toxicology, forensic molecular biology, and forensic pathology.

Concluding Remarks. The government appears to have provided sustainable resources to facilitate effective analysis of evidential materials; however, interagency cooperation can probably be improved to achieve more favorable outcomes.

Even with the advanced technologies now widely available, methodologies for effective analysis of several complex evidence categories are still lacking. For example, forensic scientists are often struggling with the analysis of mixed DNA evidence and newly emerged psychoactive substances. On the other hand, improvements in personnel training, laboratory procedures, and effective utilizations of forensic science in legal proceedings are always challenging issues.

Unsettling issues confronting the forensic science community in Taiwan are similar to those encountered in many countries in the world. For example, with the affiliation of forensic science laboratories to law enforcement agencies, the accused often do not receive the same level of forensic laboratory services available to the prosecution agencies. One may also wonder whether analytical findings, as presented by the forensic scientists working for these government laboratories, are always accurate and without bias — intentional or unintentional.

In response to these concerns — including wrongful conviction and the quality of the forensic analysis and testimony — a meeting was convened (by the Ministry of Justice) on September 13, 2018, to examine issues and discuss the establishment of national standards in forensic science. On September 21, 2018, the TAFS bylaws were revised to include a chapter on "code of ethics and conduct" in order to promote the highest quality of professional and personal conduct of the organization's members. Hopefully, progress can be made through the efforts of these initiatives.

TIAFT Delights With "Addictive Days and Toxic Nights" in Ghent

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The International Association of Forensic Toxicologists (TIAFT) held its 56th annual meeting in Ghent, Belgium, August 26–30, 2018 (**Figure 1**). It was a joint event with the Society of Hair Testing (SoHT) and the Toxicological Society of Belgium and Luxemburg (BLT). The meeting lived up to its whimsical theme of "Addictive Days and Toxic Nights".

The opening reception was held at the Museum of Fine Arts and allowed attendees to reconnect with old friends (**Figure 2**) whom they may not have seen for months or even years. The museum was the perfect venue to do this. It hosts about 9,000 works from the Middle Ages to the mid-1900s that rewarded the attention of the attendees. It also provided large social areas in which the patrons were surrounded by stunning art, as well as smaller quiet areas to catch up with colleagues.

The scientific sessions (held in the International Congress and Convention Center of Ghent) were broken into a number of important topics for the attendees: Sampling Techniques and Detection in Alternative Matrices, Drugs and Driving, New Psychoactive Substances, Postmortem Analyses, Analytical Techniques, Doping, and a session specifically dedicated to SoHT. Each session was introduced by keynote speakers who provided an overview of the topic. For example, Professor Jack Henion introduced the session on Alternative Matrices by discussing his work on the analysis of dried blood spots. Professor Johannes Ramaeckers provided an overview of his experiences with Drugs and Driving. Professor Noel Woodford discussed the challenges of postmortem toxicological analyses and interpretations. Dr. Michael Evans-Brown discussed the European Monitoring Centre for Drugs and Drug Addiction and its role related to new psychoactive substances (NPS). Dr. Markus Baumgartner explained the limitations of hair testing. And Professor Mario Thevis discussed the challenges for doping analysis. In the end, there were 90 oral presentations, 300 posters, and 5 vendor-sponsored workshops for the over 735 registrants attending the TIAFT meeting.

Figure 1. Cover of the Program and Abstract Book.

In addition to the "addictive days" offered by the scientific program, an extravagant social program helped ensure the week had opportunities for interaction and networking. One of the highlights was a midweek excursion to the fairytale city of Bruges. Attendees arrived from Ghent via a special TIAFT Express Train and were provided small-group walking tours of the historical city. When the weather turned, everyone rushed to nearby coffee shops and pubs to stay dry and share some laughs until the evening's special event began — dinner in Bruge's 13th-century belfry. The belfry stands 83 m high and houses a carillon of 48 bells. The Belgian dinner menu helped warm everyone up and as the attendees were leaving for the buses back to Ghent, we had an extra-special treat as the belfry's full-time carillonneur was playing a concert.

The meeting's farewell dinner was also very special, as it was housed in the Kuipke velodrome. During the cocktails and hors d'oeuvres, the patrons were treated to an indoor race to see which professional cyclist could claim the title of winning the first-ever TIAFT Race. Afterwards, a fabulous dinner was served, followed by dancing until after midnight. The meeting ended with final goodbyes before we see each other again at the 2019 Annual Meeting of TIAFT (September 2–6, 2019) in Birmingham, UK.

Figure 2. Reconnections of past presidents.

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International Council on Alcohol, Drugs, and Traffic Safety—2018 Regional Meeting in Prague

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The International Council on Alcohol, Drugs, and Traffic Safety (ICADTS) is an independent nonprofit body whose only goal is to reduce mortality and morbidity brought about by use of alcohol or drugs by motor vehicle operaters. The organization was formed in Stockholm, Sweden, in 1950. Since then, ICADTS has organized international conferences about every third year, in addition to regional meetings and workshops. The conferences are multidisciplinary, covering public health and safety, traffic and transport psychology, medicine, pharmacology, toxicology, forensic science, economics, law and law enforcement, public policy, education, human factors, and alcohol/drug intervention and rehabilitation.

In its almost 70-year history, ICADTS has documented tremendous progress in the field of alcohol, drugs, and traffic safety. During the first decades, the primary focus of the conferences was the incidence and prevention of driving under the influence of alcohol and alcohol-related road traffic crashes. More recently, the number of papers discussing various issues related to drug-impaired driving has increased steadily.

ICADTS welcomes new members and affiliates. To become a member, the applicant must demonstrate significant accomplishments in any of the relevant disciplines that encompass the field of alcohol, drugs, and traffic safety, including program management as well as research. Alternatively, anyone with an interest in the field of alcohol, drugs, and traffic safety can become an affiliate of ICADTS. For more information, see *www.icadtsinternational.com*.

The *ICADTS Reporter* is the official quarterly newsletter of ICADTS. It is available free of charge by writing to the editor, Kathryn Stewart, via email: Stewart@pire.org. To view past issues of the *Reporter*, go to *http://www.icadtsinternational.com/pages/icadts-reporter.php*.

Regional Meeting in Prague, September 2018

The regional ICADTS Meeting was held September 1-4, 2018, in Prague, Czech Republic. A pre-conference workshop on the effects of cannabis use on road traffic safety was held August 30, 2018. The meeting was hosted by the Transport Research Centre (CDV) in close cooperation with the Ministry of Transport of the Czech Republic. It took place in the lovely and historic Břevnov Monastery. The meeting was entitled "Current trends and challenges in alcohol, drugs, and traffic safety", and included keynote speeches and oral and poster presentations. The majority of the presenters and other attendees were from the Czech Republic and other European countries, but researchers from Australia, Brazil, and the United States attended as well.

The meeting was opened by researchers from CDV, who discussed alcohol, drugs, and road traffic safety in the Czech Republic. Three keynote speeches were given during the meeting: "Taking action in impaired driving around the world: progress, prospects and the role of ICADTS", presented by Kathryn Steward; "Driving under the influence of addictive substances as a serious social problem", presented by Zdeněk Žak; and "THC and driving", presented by Fátima Pereira da Silva. Further, the scientific sessions included presentations on alcohol and drug use and addiction in the Czech Republic; driving under the influence of alcohol or drugs in Australia, Brazil, Czech Republic, Ireland, and Norway; road traffic crash statistics; alcohol use in public transport; oral fluid testing; per-se drug legislation; prevention and rehabilitation; characteristics of DUI offenders; recreational and medicinal use of cannabis.

The New ICADTS Executive Board and T2019

The new ICADTS Executive Board was installed following the election of new officers last summer. Johannes G. (Jan) Ramaekers (The Netherlands) was welcomed as president, Jim Fell (US) as president-elect, Tara Kelley-Baker (US) as assistant secretary, Hallvard Gjerde (Norway) as assistant treasurer, and Mark King (Australia) and Maria de Fátima Pereira da Silva (Portugal) as board members-at-large. In addition, Sjoerd Houwing (The Netherlands) and Edward Ogden (Australia) have taken on the duties of treasurer and secretary, respectively, whereas Flavio Pechansky (Brazil) and Evelyn Vingilis (Canada) will keep up their good work as members-at-large for three more years.

Kathryn Stewart (US) has successfully chaired the ICADTS board for the past 3 years. She has done a tremendous job in promoting the goals of ICADTS. During her term as president, ICADTS reached out to middle- and low-income countries in particular. The main triannual meeting (T2016) was hosted in Brazil, and a regional meeting was held in Slovenia in 2017.

Looking forward, the board welcomes members to contribute to new and ongoing ICADTS activities and to join ongoing ICADTS working group activities or to launch new initiatives. Committees and working groups will have an excellent opportunity to share and discuss their activities during the 22nd International Council on Alcohol, Drugs, and Traffic Safety Conference (T2019) that will be held in Edmonton, Canada, on August 18–21, 2019 (*www.T2019.org*).

*Johannes G. Ramaekers is president of The International Council on Alcohol, Drugs, and Traffic Safety.

Upcoming Events

American Academy of Forensic Sciences — 71st Annual Meeting
Feb. 18–23, 2019; Baltimore Convention Center
Baltimore, MD, US

PITTCON Conference and Expo
March 17–21, 2019; Pennsylvania Convention Center
Philadelphia, PA, US

VI International Conference on Novel Psychoactive Substances
April 8–9, 2019; University of Maastricht
Maastricht, The Netherlands

Southern Association of Forensic Scientists — Annual Meeting
April 29–May 3, 2019; Crowne Plaza Tennis & Golf Resort
Asheville, NC, US

Mid-Atlantic Association of Forensic Scientists — Annual Meeting
May 7–10, 2019; Morgantown Marriott at Waterfront Place
Morgantown, WV, US

California Association of Criminalists Seminar — Spring 2019
May 13–17, 2019; Waterfront Hotel
Jack London Square, Oakland, CA, US

American Society of Crime Laboratory Directors — Annual Symposium
May 19–21, 2019; St. Louis Union Station Hotel
St. Louis, MO, US

The Association of Firearm and Tool Mark Examiners — 50th Annual Training Seminar
May 26–31, 2019; Gaylord Opryland Resort & Convention Center
Nashville, TN, US

3rd World Conference and Exhibition on Forensic Science
June 3–4, 2019; Hotel Novotel Berlin Mitte
Berlin, Germany

ICFS 2019: 21st International Conference on Forensic Sciences
June 27–28, 2019; Holiday Inn London—Wembley
London, UK

2nd World Conference on Analytical & Bioanalytical Chemistry
July 12–13, 2019; Trapicana Las Vegas
Las Vegas, NV, US

International Association for Identification — 2019 International Educational Conference
Aug. 11–17, 2019; Peppermill Resort
Reno, NV, US

T2019: 22nd International Council on Alcohol, Drugs and Traffic Safety Conference
Aug. 18–21, 2019; Shaw Conference Centre
Edmonton, Canada

Northwest Association of Forensic Scientists — Annual Conference
Aug. 26–30, 2019; Red Lion Hotel on the River
Portland, OR, US

TIAFT 2019: 57th Annual Meeting of the International Association of Forensic Toxicologists
Sept. 2–6, 2019; The International Convention Center
Birmingham, UK

2019 International Conference on Forensic Nursing Science and Practice
Sept. 11–14, 2019; New Orleans Marriott
New Orleans, LA, US

ISHI 2019: 30th International Symposium on Human Identification
Sept. 23–26, 2019; Palm Springs Convention Center
Palm Springs, CA, US

Society of Forensic Toxicologists — Annual Meeting
Oct. 7–11, 2019; Hyatt Regency
San Antonio, TX, US

Midwestern Association of Forensic Scientists — 48th Annual Fall Meeting
Oct. 14–18, 2019; Galt House Hotel
Louisville, KY, US

International Forum for Drug & Alcohol Testing — 2019 Conference
Oct. 16–17, 2019; Ottawa Art Gallery
Ottawa, Canada

Southwestern Association of Forensic Scientists — 41st Annual Conference
Oct. 27–31, 2019; Renaissance Austin Hotel
Austin, TX, US

Northeastern Association of Forensic Scientists — 45th Annual Meeting
Nov. 13–16, 2019; Marriott Lancaster at Penn Square
Lancaster, PA, US

2nd International Caparica Conference in Translational Forensics 2019
Nov. 18–21, 2019; Hotel Aldeia dos Capuchos Golf & SPA
Caparica, Portugal

ADVANCING THE PRACTICE OF FORENSIC SCIENCE IN THE US — UPDATE

After the US National Research Council published "Strengthening Forensic Science in the United States: A Path Forward" *(see* https://www.ncjrs.gov/app/publications/abstract.aspx?ID=250103*) in 2009, the National Institute of Standards and Technology (NIST) and US Department of Justice (DOJ) committed to a number of initiatives to strengthen the practice of forensic science.*

NIST conducts research to advance the forensic sciences, supplies forensic laboratories with physical reference standards and data to help ensure accurate test results, and administers the Organization of Scientific Area Committees for Forensic Science (OSAC), which facilitates the development of science-based standards for forensic practice.

The Forensic Technology Center of Excellence (FTCoE), a program of the NIJ, serves as a resource for both practitioners and developers. It assists in the transition of forensic technology from applied research into practice; and in conducting knowledge transfer and outreach.

The "Professional Review and Commentary" section of FSR has published previous "Updates" for both NIST (since January 2014) and for NIJ's FTCoE (since July 2014). The current semiannual "Updates" from these agencies and their programs are included in this issue.

National Institute of Standards and Technology (NIST) and NIST-Sponsored Programs

National Institute of Standards and Technology Forensic Science Updates

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Data-Sharing Website Helps Identify New Types of Fentanyl and Other Narcotics[a]

The drug-overdose epidemic currently gripping the nation is so tenacious in part because it's being driven by fentanyl, a synthetic opioid that comes in many forms. Each form has a slightly different chemical structure, and clandestine chemists are constantly cooking up new ones. From a law enforcement perspective, this makes fentanyl a moving target and very difficult to control.

To help with this situation, scientists at the National Institute of Standards and Technology (NIST), the German Federal Criminal Police Office (the *Bundeskriminalamt*, or BKA) and the US Drug Enforcement Agency (DEA) have launched a website where forensic chemists can share data on new drug variants, also called drug analogs. Described in *Forensic Chemistry*, the **NPS Data Hub** (NPS stands for Novel Psychoactive Substances) includes the chemical structures of drug analogs and their chemical signatures, which are the keys to identifying them in the lab.

Being able to identify drugs quickly is critical. "If people start overdosing and dying from a new drug analog, authorities need to identify it as quickly as possible," said Aaron Urbas, the NIST research chemist who led the project. "If you want to focus your resources effectively, you need to know what you're looking for."

The goal of the NPS Data Hub is to get drug identification data to forensic chemists more quickly. In addition to data on synthetic opioids such as fentanyl, the Data Hub is also intended to cover synthetic cannabinoids (aka synthetic marijuana), synthetic cathinones (aka bath salts), amphetamines, and other dangerous drugs.

Underground chemists create new analogs in part to boost drug potency, with some fentanyl analogs being thousands of times stronger than heroin. This increases the risk to users, who may not know exactly what they're consuming. New analogs also allow the manufacturers to stay one step ahead of the law.

When drug evidence is seized, forensic chemists will often try to identify it using an instrument such as a mass spectrometer, which generates a unique barcode-like pattern — a sort of chemical signature — for the compound in question. They will then search law enforcement databases for a known compound with the same signature. If the drug is new, the signature won't be recognized, and a much more complex analysis will be needed to identify the substance and determine its chemical structure. Few

[a]Urbas A, Schoenberger T, Corbett C, Lippa K, Rudolph F, Robien W: NPS Data Hub: A web-based community driven analytical data repository for new psychoactive substances; *Forensic Chem* 9:76; 2018; *https://www.sciencedirect.com/science/article/pii/S2468170918300559?via%3Dihub*.

labs have that capability, so the drug may need to be sent to a more advanced facility. The whole process can take six months or more, including quality control to ensure the accuracy of the chemical structure and other data.

After that process is complete, the new drug and its chemical signature are added to law enforcement databases so that it can be identified more easily next time around. "We want to shorten the time lag between discovery of a new drug and the distribution of the data needed to identify it," Urbas said.

The NPS Data Hub aims to shorten that time lag by making it easier for experts to collaborate. For instance, a chemist from one lab can analyze a new drug and upload a proposed chemical structure and supporting data to the Data Hub. Then a second chemist from a different lab can review the data and confirm the proposed structure or suggest a new one.

"These people have very rare expertise," said NIST senior policy advisor Jayne Morrow. "The Data Hub brings these experts together and provides a forum where they can discuss what they're seeing in real time. There haven't been great ways to do that before, and it's really needed." Only labs with sufficient capabilities can propose and confirm chemical structures. But other labs, including smaller state and local labs, can use that data.

In addition to the collaboration mechanism, the NPS Data Hub differs from existing drug databases in two ways. First, many databases only include chemical signatures based on commonly used techniques such as mass spectrometry. The NPS Data Hub permits sharing of analytical data from any technique, including nuclear magnetic resonance (NMR), Raman spectroscopy, and others that, though less common, can be useful for differentiating closely related compounds.

Second, in commonly used drug databases such as the one maintained by the Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG), the information is highly vetted for quality control. That makes SWGDRUG data authoritative, but the vetting takes months to complete. The NPS Data Hub is meant to be less authoritative but updated more frequently.

"The Data Hub can contain both curated and preliminary data, so you wouldn't necessarily use it to produce courtroom evidence," Urbas said. "But for tracking the emergence of new drug analogs, even preliminary data can make a huge difference. NPS Data Hub accounts are only available for users with suitable law enforcement, public health, or research credentials. For more information, visit the NPS Data Hub page on the NIST website (*https://www.nist.gov/programs-projects/novel-psychoactive-substance-nps-data-hub*).

New Protocol for Measuring Background Levels of Drugs in Crime Labs[b]

When crime-lab chemists handle evidence that contains illegal drugs, trace amounts of those drugs are inevitably released into the laboratory environment. When chemists scoop a bit of powder to test it, for instance, microscopic particles can become airborne and later settle on nearby surfaces. Particles can also be spread by touch. To some degree, this is an unavoidable byproduct of the testing process, and it can result in detectable background levels of drugs in the lab. Now, scientists at NIST and the Maryland State Police Forensic Sciences Division have developed a protocol for measuring those levels and have used their new protocol at three forensic chemistry labs. Their findings have been published in *Forensic Chemistry*.

Best practices recommend regular cleaning of surfaces to remove drug residues, but few labs currently monitor background levels. That might have to change as superpotent drugs like fentanyl, the synthetic opioid driving the nationwide overdose epidemic, become more common. Small amounts of fentanyl are often mixed into other drugs to boost their potency, and labs may have to increase the sensitivity of their instruments to detect those small amounts. If background levels are too high, that can potentially affect the test results reported by the lab.

"If I run a sample and it has fentanyl, I want to be sure that fentanyl came from the sample and not from background levels in my lab," said NIST research chemist Ed Sisco, the lead author of the study.

To measure those levels, the authors swabbed laboratory surfaces in the same way that airport security agents might swab a passenger's hands or luggage. At the airport, that swab would go into an instrument that tests for traces of explosive residue. In this study, the authors tested the swabs for traces of narcotics. They swabbed laboratory benches, balances, telephones, and door handles. They also swabbed outside the lab space, in evidence-receiving areas, and in office spaces. To ensure that the measurements reflected routine conditions at the lab, no unscheduled cleaning took place prior to testing.

To identify which drugs were present, the researchers used a technique called direct analysis in real-time mass spectrometry (DART-MS). They then used liquid chromatography tandem mass spectrometry (LC/MS/MS) to measure how much of each drug was present.

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[b]Sisco E, Najarro M, Bums A: A snapshot of drug background levels on surfaces in a forensic laboratory; *Forensic Chem* 11:47; 2018; *https://www.sciencedirect.com/science/article/pii/S2468170918300730?via%3Dihub*.

"If you push your sensitivity enough, you'll find narcotics on almost everything," and not just in chemistry labs, according to NIST research chemist and co-author Marcela Najarro. The authors cited a 2011 study that found detectable amounts of cocaine on 75% of shopping carts, ATM machines, and other frequently touched surfaces in public places.

At the labs they tested, the researchers detected at least 13 different substances, including fentanyl, heroin, cocaine, oxycodone, and methamphetamine. For fentanyl, the average level detected was 2 ng per square centimeter, and the highest level was 55 ng per square centimeter. "That level of background wouldn't affect measurements at most labs because most labs don't look down that far when testing evidence," said co-author Amber Burns, a forensic chemist with the Maryland State Police. "But knowing those numbers can be important if a lab is considering an increase in their sensitivity."

Some other interesting findings: The balances that chemists use to weigh evidence contained up to 10 times more drug residue than other surfaces. This suggests one relatively easy way that labs can reduce background levels. Also, different labs had different contamination profiles. One of the labs had higher levels of cocaine while another had more opioids, which reflected the mix of cases handled at each lab.

The authors detailed their protocol so that other labs could reproduce it, with recommendations on how to swab and where, and how to analyze and report the results. In a follow-up study, they will investigate lower-cost methods so labs can more easily afford to conduct regularly scheduled tests. They also plan to partner with experts from the National Institute for Occupational Safety and Health, who will assess the potential effects of background levels on workplace safety.

In the meantime, they hope their research will provide a reliable protocol that any lab can follow. "You can't completely eliminate background levels of drugs," Sisco said. "But you can measure it to make sure it's low enough, and that it stays low."

NIST Builds Statistical Foundation for Next-Generation Forensic DNA Profiling[c]

DNA is often considered the most reliable form of forensic evidence, and this reputation is based on the way DNA experts use statistics. When they compare the DNA left at a crime scene with the DNA of a suspect, experts generate statistics that describe how closely those DNA samples match. A jury can then take those match statistics into account when deciding guilt or innocence.

These match statistics are reliable because they're based on rigorous scientific research. However, that research only applies to DNA fingerprints, also called DNA profiles, that have been generated using current technology. Now, scientists at NIST have laid the statistical foundation for calculating match statistics when using next-generation sequencing (NGS), which produces DNA profiles that can be more useful in solving some crimes. This research, which was jointly funded by NIST and the FBI, was published in *Forensic Science International: Genetics*.

"If you're working criminal cases, you need to be able to generate match statistics," said Katherine Gettings, the NIST biologist who led the study. "The data we've published will make it possible for labs that use NGS to generate those statistics."

To generate a DNA profile, forensic labs analyze sections of DNA, called genetic markers, where the genetic code repeats itself, like a word typed over and over again. Those sections are called short tandem repeats (STRs), and the number of STRs at each marker varies from person to person. The analyst doesn't actually read the genetic sequence inside those markers, but just counts the number of STRs at each one. That yields a series of numbers that, like a long social security number, can be used to identify a person.

STR-based profiling was developed in the 1990s, when genetic sequencing was hugely expensive. Today, NGS makes sequencing cost-effective for biomedical research and other applications. NGS can also be used to create forensic DNA profiles that, unlike traditional STR profiles, include the actual genetic sequence inside the markers. That provides a lot more data.

That extra data might not be needed because in most cases, STR-based profiles contain more than enough information to reliably identify a suspect. However, if the evidence contains only a minute amount of DNA, or if the DNA has been exposed to the elements and has begun to break down, then the analyst might only get a partial profile, which may not be enough to identify a suspect. In those cases, the extra data in an NGS-based profile might help solve the case. In addition, evidence that contains a mixture of DNA from several people can be difficult to interpret. The extra data in NGS-based profiles can help in those cases as well.

DNA analysts are able to calculate match statistics for STR-based profiles because scientists have measured

[c]Gettings KB, Borsuk LA, Steffen CR, Kiesler KM, Vallone PM: U.S. population sequence data for 27 autosomal STR loci*; Forensic Sci Int Genetics* 37:106; 2018; *https://www.fsigenetics.com/article/S1872-4973(18)30247-3/pdf*.

how frequently different versions of the markers occur in the population. With those frequencies, you can calculate the chances of randomly encountering a particular DNA profile, just as you can calculate the chances of picking all the right numbers in a lottery.

NIST measured those STR gene frequencies years ago using a library of DNA samples from 1,036 individuals. To calculate gene frequencies for NGS-based profiles, Gettings and her co-authors cracked open the freezer that contained the original samples, which were anonymized and donated by people who consented to their DNA being used for research. The scientists generated NGS-based profiles for them by sequencing 27 markers — the core set of 20 included in most DNA profiles in the United States plus seven others. They then calculated the frequencies for the various genetic sequences found at each marker.

It might be surprising that scientists can estimate gene frequencies from such a small library of samples. However, the NIST team was measuring frequencies not for the full profiles, but for the individual markers. Since they sequenced 27 markers, with each marker occurring twice per sample, the number of markers tested wasn't 1,036, but more than 55,000.

Although NIST has now published the data needed to generate match statistics for NGS-based profiles, other hurdles must still be cleared before the new technology sees widespread use in forensics. For instance, labs will have to develop ways to manage the greater amounts of data produced by NGS. They will also have to implement operating procedures and quality controls for the new technology. Still, while much work remains, said Peter Vallone, the research chemist who leads NIST's forensic genetics research, "We're laying the foundation for the future."

NIST Updates Forensic Standard Reference Materials

To help ensure accuracy, NIST manufactures physical standards that are used to calibrate analytical instruments in much the same way that a precisely manufactured kilogram mass can be used to calibrate a scale. These standard reference materials (SRMs) take many forms. NIST recently released updated versions of two forensic SRMs — the standard bullet and the human DNA quantitation standard.

SRM 2460a: The Standard Bullet. The NIST standard bullet isn't a real bullet, but it looks like a typical 9-mm bullet that has been fired from a gun. A series of six parallel markings appear on its surface, and if you turn it under a light, you can see that those markings are made up of fine striations, which are reproduced precisely on each standard bullet, down to the microscopic level.

Those striations are meant to simulate the impressions that a gun leaves, like a ballistic signature, on every bullet it fires. For instance, if investigators recover a bullet from a crime scene, they can test-fire a suspect's weapon to produce a second bullet, then compare the ballistic signatures to see if the two bullets might have been fired from the same gun.

In many forensic firearms labs, examiners compare bullets visually under a split-screen microscope. But at state-of-the-art laboratories, they use scanning optical microscopes that measure the 3D features on a bullet's surface, including the microscopic detail within the striations. This provides greater detail and accuracy than a 2D comparison.

A firearms examiner can test whether their 3D surface scanning microscope is properly calibrated by measuring the striations on the NIST standard bullet. They then compare those measurements with data provided by NIST. If their measurements are off, they know that something is amiss.

Many labs perform these tests regularly for quality control. "This is one way to catch problems quickly," said NIST physical scientist Thomas Brian Renegar, who led the standard bullet project. "That way you can diagnose and fix the problem before doing additional casework."

The prior version of the standard bullet, which was manufactured using a diamond-turning process that engraved the striations onto the bullet, cost more than $2,000 each. With funding from the National Institute of Justice, Renegar developed a new manufacturing method that involves casting polyurethane copies in a mold, then plating them with nickel and gold. This new method allows NIST to sell the standard bullet for $350.

SRM 2372a: The Human DNA Quantitation Standard. This SRM comprises three vials, each containing human DNA suspended in a clear solution. The first vial contains DNA from a male, the second contains female DNA, and the third contains both female and male DNA in a three-to-one ratio.

Forensic analysts use this SRM when generating a genetic fingerprint, also called a DNA profile, of a suspect. If blood or other biological evidence is found at a crime scene, the analyst extracts DNA from the evidence, then processes it to generate the profile.

For this to work properly, the analyst needs to know how much DNA is in the extract before they process it. "Put in too little, and you might end up with an incomplete

DNA profile," said Erica Romsos, the research scientist at NIST who managed production of this standard. "Put in too much, and you can blow out the signal, making the results difficult to interpret."

The three vials in this standard contain precisely measured quantities of human DNA, which forensic analysts use to calibrate their instruments when measuring how much DNA they extracted from the evidence. This helps ensure that they process the right amount of DNA when generating the profile.

In the new version of this standard, the quantity of DNA in each of the vials was measured using an advanced technique called digital PCR. This gives a more precise measurement than was possible in the prior version and allows for more accurate calibrations in the lab. In addition, the prior version only listed quantities for the type of DNA that is found in the nucleus of the cell. The new version also lists the quantity of mitochondrial DNA, which is found outside the nucleus and can be useful when working with evidence that contains damaged or degraded DNA.

Other Forensic SRMs. These are just two of the forensic SRMs that NIST manufactures. NIST also produces other SRMs used in ballistics and DNA labs, as well as alcohol solutions used to calibrate breathalyzers, ignitable liquids used in arson investigations, and more. Although the types of forensic SRMs vary, they are all manufactured with the same goal in mind: To help ensure the reliability of the scientific evidence used in criminal investigations.

Drone Forensics Gets a Boost with New Data on NIST Website

Aerial drones might someday deliver online purchases to your home. But in some prisons, drone delivery is already a thing. Drones have been spotted flying drugs, cell phones, and other contraband over prison walls, and in several cases, drug traffickers have used drones to ferry narcotics across the border.

If those drones are captured, investigators will try to extract data from them that might point to a suspect. But there are many types of drones, each with its own quirks, and that can make data extraction tricky. It would help if investigators could instantly conjure another drone of the same type to practice on first, and while that may not be possible, they can now do the next best thing: Download a "forensic image" of that type of drone.

A forensic image is a complete data extraction from a digital device, and NIST maintains a repository of images made from personal computers, mobile phones, tablets, hard drives, and other storage media. The images in NIST's **Computer Forensic Reference Datasets** (CFReDS), contain simulated digital evidence and are available to download for free. Recently, NIST opened a new section of CFReDS dedicated to drones, where forensic experts can find images of 14 popular makes and models, a number that was expected to grow to 30 by December 2018.

"The drone images will allow investigators to do a dry run before working on high-profile cases," said Barbara Guttman, manager of digital forensic research at NIST. "You don't want to practice on evidence." The drone images were created by VTO Labs, a Colorado-based digital forensics and cybersecurity firm. NIST added the images to CFReDS because that website is well-known within the digital forensics community. "Listing the drone images there is the fastest way to get them out to experts in the field," Guttman said.

Work on the drone images began in May of last year, when VTO Labs received a contract from the Department of Homeland Security's (DHS) Science and Technology Directorate. "When we proposed this project, there was little existing research in this space," said Steve Watson, chief technology officer at VTO. The drone research was needed not only to combat drug smuggling, but also to allow officials to respond more quickly should a drone ever be used as a weapon inside the United States.

For each make and model of drone he studied for this DHS-funded project, Watson purchased three and flew them until they accumulated a baseline of data. He then extracted data from one while leaving it intact. He disassembled a second and extracted data from its circuit board and onboard cameras. With the third, he removed all the chips and extracted data from them directly. He also disassembled and extracted data from the pilot controls and other remotely connected devices.

"The forensic images contain all the 1s and 0s we recovered from each model," Watson said. The images were created using industry standard data formats so that investigators can connect to them using forensic software tools and inspect their contents. The images for each model also come with step-by-step, photo-illustrated teardown instructions. Watson was able to retrieve serial numbers, flight paths, launch and landing locations, photos and videos. On one model, he found a database that stores a user's credit card information.

Investigators can use the images to practice recovering data, including deleted files. Universities and forensic labs can use them for training, proficiency testing, and research. And application developers can use the images to test their software. "If you're writing tools for drone forensics, you need a lot of drones to test them on," Guttman said.

A description of the drone images and instructions for accessing them are available on the new drones section of the CFReDS website (*https://www.nist.gov/programs-projects/computer-forensic-reference-data-sets*).

Computer Games Added to National Software Reference Library

Digital Forensics Experts Use NIST's National Software Reference Library to Speed Their Investigations. One of the largest software libraries in the world just grew larger. The **National Software Reference Library** (NSRL), which archives copies of the world's most widely installed software titles, has expanded to include computer game software from three popular PC gaming distribution platforms — Steam, Origin, and Blizzard.

The NSRL, which is maintained by computer scientists at NIST, allows cybersecurity and forensics experts to keep track of the immense and ever-growing volume of software on the world's computers, mobile phones, and other digital devices. It is the largest publicly known collection of its kind in the world.

The NSRL does not loan out the software in its collection. However, NIST runs every file in the NSRL through an algorithm that generates a digital "fingerprint" — a 60-character string of letters and numbers, also known as a hash, that uniquely identifies that file. Every quarter, NIST releases an updated list of hashes to the public. The list, which NIST calls the **Reference Data Set** (RDS), now contains more than 40 million hashes, including those for the recently added video game files, and can be freely downloaded from the agency's website.

To people who work in the fields of cybersecurity and digital forensics, the world is a vast and ever-rising ocean of digital objects. The RDS allows them to navigate that ocean and quickly find what they're looking for. Many crimes today involve some form of digital evidence, and the NSRL helps investigators to process that evidence more quickly. If investigators have a seized hard drive or mobile phone, for instance, they can quickly hash all the files on that device, then compare that hash list to NIST's RDS. All the files that match can be typically ignored because they are known software files that wouldn't contain information relevant to the investigation.

"After they filter out all of the known files, they're left with everything that's not recognized," said Doug White, the NIST computer scientist who runs the NSRL. "Those are the files that might be interesting." Digital forensic investigators at all levels of government and in private industry rely on the RDS to efficiently manage their caseload.

The NSRL contains operating system software, office software, media players, device drivers — all types of software files that are commonly installed on personal computers. In 2016, the NSRL expanded to include hundreds of thousands of mobile apps, which extended its usefulness to mobile phones.

The recent addition of gaming software to the NSRL reflects the growing popularity of that software category. "We're not watching what gamers are doing," White said. "But we need to include gaming software in the NSRL if we want to stay relevant." Among the video game titles added to the NSRL are "PlayerUnknown's Battlegrounds", "World of Warcraft", and "Mass Effect".

"These games are insanely popular," said Eric Trapnell, a NIST computer scientist who helped curate the collection and is a gamer in his spare time. "Some of them have install bases in the millions."

Many of the titles were donated to the NSRL by Valve Software, which owns the Steam platform; Electronic Arts, which owns Origin; and Activision Blizzard, which owns Blizzard. Other titles were purchased if their install base was large enough to justify the expense. All titles in the NSRL are properly licensed and acquired.

While the NSRL exists primarily to support cybersecurity and law enforcement efforts, it is also considered a repository of culturally significant digital artifacts. While important books, films, and audio recordings are preserved at the Library of Congress, the NSRL functions as a national software archive. Historians consider this important because most of modern culture is both produced and consumed using software.

"Think of all the PowerPoints and Word documents that have tremendous historical significance," said Trevor Owens, head of Digital Content Management at the Library of Congress. He might have added digital artworks, maps, and interactive media. "Those documents might be lost, if future historians don't have access to a comprehensive collection of software."

An earlier batch of video games was added to the NSRL two years ago, including first editions of "Mario Bros.", "Asteroids", and "Sim City", preserving these retro titles and associated artwork for posterity. While law enforcement professionals and digital culture geeks might seem strange bedfellows, White says he's not surprised by their shared interest in the software library. "We preserve the software and make the RDS available to the public," White said. "The more people who find that useful, the better."

National Institute of Justice (NIJ) and NIJ-Sponsored Programs

Forensic Technology Center of Excellence: Updates on Sexual Assault Special Initiative

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The National Institute of Justice's Forensic Technology Center of Excellence (NIJ FTCoE) leads a comprehensive federal effort that includes a focus on systemic challenges that impede the criminal justice response to sexual assaults in the United States. The NIJ FTCoE promotes knowledge and best practices of sexual assault evidence collection and investigation for sexual assault nurse examiners (SANEs), sexual assault forensic examiners (SAFEs), and collaborative sexual assault response teams (SARTs). This FTCoE sexual assault initiative began in 2012 and supports the NIJ's efforts in research, development, testing, and evaluation processes in all areas of forensic science (*see* **Figure 1**).

Organizing and Transferring SANE/SAFE/SART Knowledge and Best Practices (2014)

As part of the NIJ FTCoE's sexual assault initiative, two stakeholder meetings and a policy forum were led to identify gaps in education and policies governing sexual assault response. This comprehensive effort helped establish a report that provides recommendations and guidance to improve the knowledge and best practices of SANEs, SAFEs, and collaborative SARTs. The goal of this effort was to ensure that existing research, information, and best practices were being made available to the entire community. The NIJ FTCoE has used this effort to develop resources and educational tools to support additional efforts to lessen gaps and address needs toward improving the response to sexual assault across the criminal justice system. These discussions and forums culminated in a final report (*https://rti.connectsolutions.com/p6quq6euyx2/*) and the Best Practices: Sexual Assault Investigations-Policy Forum (*https://rticqpub1.connectsolutions.com/content/connect/c1/7/en/events/event/shared/1176846289/event_landing.html?sco-id=1178562392&_charset_=utf-8*).

National Best Practices for Sexual Assault Kits Mobile Application (Anticipated Early 2019)

A victim's first impression of the criminal justice system happens during the forensic exam and the initial steps to reporting to law enforcement. This critical step in the path to justice for victims is addressed in the NIJ report, *National Best Practices for Sexual Assault Kits (NBPSAK): A Multidisciplinary Approach* (*https://nij.gov/topics/law-enforcement/investigations/sexual-assault/Pages/national-best-practices-for-sexual-assault-kits.aspx*). To provide this valuable resource to practitioners in a dynamic format, the NIJ FTCoE is developing a mobile application in collaboration with AB Castner Technologies, LLC (Morrisville, PA). The NBPSAK mobile application will ensure on-the-go access to the recommendations and guidance from the Sexual Assault Forensic Evidence Reporting (SAFER) Act working group and also will

Figure 1. The NIJ FTCoE is identifying gaps and addressing needs across the criminal justice system's response to sexual assault. This timeline illustrates the NIJ FTCoE's commitment to understanding and educating on a variety of topics for sexual assault evidence collection and investigation for SANEs, SAFEs, and collaborative SARTs.

incorporate links to external sites and additional resources for further guidance. Once launched, the mobile application will be expanded to provide users access to FTCoE and NIJ resources on sexual assault response.

Multidisciplinary Sexual Violence Glossary (2015–Present)

In partnership with the Center for Nursing Excellence International (CFNEI), the NIJ FTCoE has worked to meet the expressed needs of professionals and organizations responding to sexual violence through the creation of a web-based, searchable **Multidisciplinary Sexual Violence Glossary**. Terminology can vary greatly among different stakeholders during evidence collection and investigations of sexual assault. The glossary includes terms and definitions related to sexual assault, including special populations: Human trafficking, child exploitation, and pornography; elders; lesbian, gay, bisexual, transgender, queer/questioning (LGBTQ); and death investigations. The Multidisciplinary Sexual Violence Glossary defines many medical terms for sexual assault evidence collection and investigations, with schematics or diagrams of the body location. Providing quick, easy access to common terminology, medical definitions, and slang terminology both enhances collaboration between disciplines and helps practitioners understand the terms that victims might use during this traumatic and sensitive time. To meet the needs of practitioners, CFNEI works with multidisciplinary subject matter experts who contribute to developing the terms list, writing associated definitions, and reviewing the multidisciplinary definitions. The Multidisciplinary Sexual Violence Glossary includes more than 3,500 terms and averages more than 4,000 visitors each month. To ensure that the glossary makes an impact, it is continually expanded to include additional terms related to the multidisciplinary response to sexual violence. Additionally, anyone can suggest inclusion of terms for future updates to the Multidisciplinary Sexual Violence Glossary through an online feedback tool. The NIJ FTCoE and CFNEI will continue to update the glossary and ensure that definitions are compliant with the FBI quality assurance standards to maintain consistency in federal documents. The glossary is currently available at *https://www.cfnei.com/glossary-index/*.

Resources to Enhance the Criminal Justice Response to Sexual Assault (2015–Present)

In addition to the mobile application to provide access to the NBPSAK report, the NIJ FTCoE is also working to address the report's recommendation for law enforcement personnel and criminal justice professionals who work with sexual assault victims to receive training in the neurobiology of trauma and specialized skills for interviewing sexual assault victims. By ensuring the criminal justice response to sexual assault is focused on victims, victim support services will be improved and victim engagement in the criminal justice process will be increased, thus improving sexual assault case outcomes. The NIJ FTCoE works to identify gaps and provide access to resources that feature key topics to organize and transfer knowledge and best practices of sexual assault response. The NIJ FTCoE and partners are developing resources that include reports and guidance for the criminal justice community. Two upcoming publications are:

- *Beyond DNA: The Impact of Physical Evidence in Sexual Assault Investigations*, a report to inform on non-DNA sexual assault evidence types and currently available technologies that can help; and
- *Evidence Processing of Groping Cases*, a guidance document that evaluates criminal justice implications for investigating and prosecuting forensic evidence obtained from groping cases.

The NIJ FTCoE also provides access to webinars and online workshops; those currently available include:

- Advancing Research Initiatives and Combatting the Human Trafficking Epidemic;
- Navigating the Sea of Resources for Sexual Assault Programs;
- Drug-Facilitated Sexual Assault Workshop, Sexual Assault on Campus and Forensic Nursing Symposium; and
- Looking Ahead: The National Sexual Assault Policy Symposium.

The NIJ FTCoE is currently partnering with Duquesne University (Pittsburgh, PA) and additional subject matter experts to develop a webinar series, entitled *Improving the Response to Sexual Assault Within Special Populations*, which discusses important considerations to best support each victim in his/her unique circumstances with improved investigative and forensic examination techniques. Two webinar in the series are currently available including "Providing Gender Inclusive Care to Victims of Sexual Assault" and "Responding to Sexual Assault Victims of Color". The FTCoE also features key topics in sexual assault as part of the *Just Science* podcast, including "Just the Facts About Campus Sexual Assault", an episode discussing the problem of sexual assault on college campuses and prisons and an episode featuring a sexual assault case-study interview. All webinars and podcasts are available on the Resources tab or by searching the specific title on *https://forensiccoe.org/sexual-assault/*.

NEW BOOKS AND BOOK REVIEW

New Forensic Science Books

A Life of Crime: My Career in Forensic Science
D. Lucas
CRC Press: Boca Raton, FL, US; 2018

Automated Ballistic Identification Systems
G. Bailey
Academic Press/Elsevier: Waltham, MA, US; 2018

***Chemical Analysis of Firearms, Ammunition, and Gunshot Residue*, 2nd ed**
J. S. Wallace
CRC Press: Boca Raton, FL, US; 2018

Detection of Drugs and Their Metabolites in Oral Fluid
R. White, C. Moore
Academic Press/Elsevier: Waltham, MA, US; 2018

Digital Forensic Art Techniques: A Professional's Guide to Corel Painter
N. Murry
CRC Press: Boca Raton, FL, US; 2018

Dismemberments: Perspectives in Forensic Anthropology and Legal Medicine
A. Ross, E. Cunha, Eds
Academic Press/Elsevier: Waltham, MA, US; 2018

Engineering Standards for Forensic Application
R. McLay, R. Anderson, Eds
Academic Press/Elsevier: Waltham, MA, US; 2018

***Fingerprint Analysis Laboratory Workbook,* 2nd ed**
H. M. Daluz
CRC Press: Boca Raton, FL, US; 2018

Fingerprint Development Techniques: Theory and Application
S. M. Bleay, R. S. Croxton, M. De Puit
Wiley-Blackwell: Somerset, NJ, US; 2018

Firearm and Tool Mark Identification: The Scientific Reliability of the Forensic Science Discipline
R. Nichols
Academic Press/Elsevier: Waltham, MA, US; 2018

Forensic Anthropology: Theoretical Framework and Scientific Basis
C. C. Boyd, D. C. Boyd, Eds
Wiley-Blackwell: Somerset, NJ, US; 2017

Forensic Ecogenomics: The Application of Microbial Ecology Analyses in Forensic Contexts
T. K. Ralebitso-Senior
Academic Press/Elsevier: Waltham, MA, US; 2018

Forensic Human Factors and Ergonomics: Case Studies and Analyses
M. S. Wogalter
CRC Press: Boca Raton, FL, US; 2018

***Fundamentals of Fingerprint Analysis,* 2nd ed**
H. M. Daluz
CRC Press: Boca Raton, FL, US; 2018

***Handbook of Forensic Toxicology for Medical Examiners,* 2nd ed**
D. K. Molina, V. Hargrove
CRC Press: Boca Raton, FL, US; 2018

Instrumental Data for Drug Analysis,* 2nd ed; *Volume VII: Cumulative Indices
T. Mills III, J. C. Roberson, C. C. Matchett, M. J. Simon, M. D. Burns, R. J. Ollis Jr
CRC Press: Boca Raton, FL, US; 2018

Introduction to Forensic Chemistry
K. M. Elkins
CRC Press: Boca Raton, FL, US; 2018

Investigating Windows Systems
H. Carvey
Academic Press/Elsevier: Waltham, MA, US; 2018

Multidisciplinary Medico-Legal Death Investigation: Role of Consultants
L. Sathyavagiswaran, C. B. Rogers, Eds
Academic Press/Elsevier: Waltham, MA, US; 2018

Neurocriminology: Forensic and Legal Applications, Public Policy Implications
D. Concannon
CRC Press: Boca Raton, FL, US; 2018

***Practical Crime Scene Processing and Investigation,* 3rd ed**
R. M. Gardner, D. Krouskup
CRC Press: Boca Raton, FL, US; 2018

Quality Management in Forensic Science
S. Doyle
Academic Press/Elsevier: Waltham, MA, US; 2018

***Scientific Protocols for Fire Investigation,* 3rd ed**
J. J. Lentini
CRC Press: Boca Raton, FL, US; 2018

***Successful Expert Testimony,* 5th ed**
M. M. Houck, C. Funk, H. Feder, Eds
CRC Press: Boca Raton, FL, US; 2018

***The Forensic Crime Scene, A Visual Guide,* 2nd ed**
M. Miller, P. Massey
Academic Press/Elsevier: Waltham, MA, US; 2018

Book Review

Forensic Evidence Management: From the Crime Scene to the Courtroom

Ashraf Mozayani, Casie Parish Fisher, Eds
CRC Press: Boca Raton, FL, US; 2017

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Forensic Evidence Management: From the Crime Scene to the Courtroom serves as a valuable overview of all evidence types. Creating and maintaining the best available standards for identifying and processing each type of forensic evidence comes as a great challenge when attempting to implement those standards across a diverse population. This book provides an outline of every evidence type and how to identify each type, as well as general guidelines for the proper preservation and collection of each type of evidence.

The editors of this book made a remarkable effort to bring in a variety of contributors. These contributors are those noted as experts in their disciplines with numerous years of practitioner experience that cannot be replaced. Biographies of each contributor are made available and bolster the confidence in the reader as they proceed through each discipline. The value of having minds with empirical knowledge allows for not only a more well-rounded overview of the topics but also the unique ability to draw on past experiences and lessons learned in order to provide a realistic summary of the highest-quality evidence preservation techniques.

The editors chose to begin this text at the most important starting line, which is the crime scene. Most all evidence originates at the crime scene and if improper procedures or protocols are employed, or uneducated decisions are made, the evidence has the potential to lose all value. The authors provide a guide of the best practices to: (a) maintain the integrity of the crime scene and the evidence; (b) properly document the details of that crime scene and collect each item of evidence; and (c) adequately prepare the items for transport to and analysis in the laboratory.

Each chapter of this book is dedicated to a specific type of evidence. Each section is structured in a systematic format to allow the reader to first be introduced to the identification of the evidence and then proper documentation of said item. The text for each chapter then provides a wide overview of the variety of methods to preserve and collect each evidence type while also placing great emphasis on the complications each type of evidence presents. For example, the delicate nature of latent fingerprints in addition to the environmental packing and storage concerns of biological evidence are discussed. Each chapter then goes on to provide a brief exposure to how this evidence may be analyzed in the laboratory as well as evidence and findings presented in a court of law. With such a diverse variety of topics and potential evidence presented, the authors provided extremely useful guidance through the use of charts and diagrams. For example, in the Trace Evidence section, the author provides a simple explanation to educate the reader on not only how the evidence is collected but also how it is being analyzed. Various examples and diagrams provide useful explanatory tools, especially for those readers not familiar with trace evidence analysis or how the evidence is effectively processed in a laboratory. There are examples of these resources throughout each chapter to afford a quick and easy guide to determine things such as preservation criteria for biological evidence specimens, hazard assessment at unique scenes, or even the advantages and disadvantages of multiple types of toxicology specimens.

As a valuable conclusion to this collection of disciplines, this book closes with a chapter discussing the most important challenges faced by those in the field of forensics — including ethics and bias. Standardization also is a constant challenge in the field of forensics inasmuch as forensics is met with a multitude of variables. Geography and resources often may dictate the capabilities of a forensic scientist, and the ability to think outside of the box is a priceless skill. The authors summarize these skills and lay great emphasis on the significance of objectivity among forensic professionals. From the crime scene, to the transportation of evidence, to the laboratory analysis, then to the courtroom presentation, the actions taken require a constant focus on the highest quality of decision-making. The authors make certain to discuss the Code of Professional Responsibility that all forensic practitioners should abide by throughout their work. These developed guidelines furnish the forensic community with the structure and backbone for the ethical choices that are made with analysis of each piece of evidence. The work of forensics is ultimately still completed by analysts — which means there is never to be an absence of error or bias. The authors do an admirable job of summarizing this fact as they discuss in detail the cognitive and contextual biases affecting the forensic community, as well as efforts made across all disciplines to mitigate and manage the frequency and impact of these occurrences.

This book is a valuable guide whether one is a crime scene investigator determining how to collect evidence or an administrator making decisions on how to best store and maintain all forms of evidence efficiently and effectively while maintaining the evidence integrity and warding off any possibilities for contamination or deleterious change. The overview provided on each discipline and evidence type allows for a novice in the profession to obtain a clear understanding of general information on each topic as well as focus on the most important aspects of evidence items to effectively preserve those items. Overall this book is a comprehensive outline for all evidence types and a resource for law enforcement, crime scene investigators, scientists, and administrators.

TEITELBAUM'S COLUMN ON FORENSIC SCIENCE — HISTORICAL PERSPECTIVE —

Who Made That Ladder? Arthur Koehler and the Lindbergh Kidnapping Case

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"Wood forensics" was never on a bigger stage than during the 1932–1936 Lindbergh kidnapping case, when law enforcement personnel across the United States worked feverishly to determine who had kidnapped the infant son of famed aviator Charles Lindbergh and his wife Anne Morrow Lindbergh from their New Jersey home. The person who, in many respects, did more to solve the case than anyone was a wood specialist named Arthur Koehler (1885–1967) (**Figure 1**). Although he became a household name for a few years for his role in helping to convict the kidnapper, with newspapers naturally dubbing him the "Sherlock Holmes of the Forest", Koehler was not a criminologist but, rather, a wood technologist who worked for the Forest Products Laboratory in Madison, Wisconsin.

From the moment that Arthur Koehler read about the homemade wooden ladder that was apparently used in the kidnapping of the Lindbergh child, he knew that he could help. His entire professional career had been spent analyzing wood: Examining the growth of trees, studying the cellular structure of every type of wood imaginable, understanding how wood differs from region to region and how each type can be identified. He actually wrote a letter to Lindbergh offering his help, but it wasn't until May 1932, 10 weeks after the kidnapping, that Koehler received some slivers of wood from the ladder to examine [1]. The New Jersey State Police had been taking the ladder from one expert to another, looking for clues, and sending some slivers to the Forest Products Laboratory was their latest effort.

Eagerly examining the slivers with his microscope, Koehler quickly determined that several different types of wood were represented — Douglas fir, ponderosa pine, a strip of birch — knowing immediately which part of the country each type of wood came from; and he also found several woolen fibers, which he described in his report as possibly coming from the clothing of the person who used the ladder. Almost another whole year passed before he was requested to report to the New Jersey State Police department in Trenton, where, for the first time, he was finally able to see the actual three-piece ladder (**Figure 2**). One of the first things he learned was that the woolen fibers he had found during his examination of the ladder slivers did not belong to the kidnapper. The fibers came from the wool blanket in which the troopers had wrapped the ladder while transporting

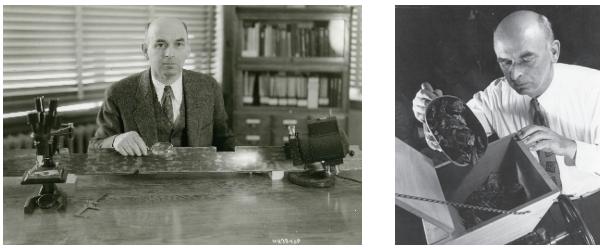

Figure 1. Arthur Koehler (1885–1967) (Courtesy of USDA Forest Products Laboratory: Madison, WI; Forest History Society: Durham, NC).

it. The second thing he learned from examining the ladder was that it had been handmade by someone who was, in his words, a "slovenly carpenter". The ladder design was second-rate, it had been gouged and shaved by a dull chisel, and the crosspieces were uneven, but the crude workmanship would provide a surfeit of clues. He noticed that there was absolutely no rust around any of the nails, which indicated that it had probably never been stored outside. He used oblique lighting to make milling marks visible. He took the ladder completely apart and examined it for four days with his microscope and calipers and made an exhaustive inventory of every part. Rail 16, the number he had given one of the vertical rails, was particularly interesting in that it had four square-cut nails holes in it — holes that had no purpose in terms of the ladder's construction. Also, the rail was not made from new wood, like the rest of the ladder parts, but had been cut from another previously used piece.

Studying the pine ladder rails, Koehler determined that the planing machine from the mill that had cut this wood had been fitted with six edge-cutting blades and eight face-cutting blades. He was also able to determine the speed at which the wood had been cut. With this information, and knowing that this low-quality wood would not have been shipped from a long distance away, he sent letters to 1,600 mills in the southern United States pine region. Only 25 mills responded that they used the eight- and six-blade configuration and that they could mill the wood at the stipulated speeds. They also provided wood samples at Koehler's request,

Figure 2. The 3-piece ladder (Courtesy of USDA Forest Products Laboratory: Madison, WI ; Forest History Society: Durham, NC).

and one of the samples, from the McCormick Mill in South Carolina, matched perfectly! He immediately traveled to the McCormick Mill and was soon convinced that the wood had indeed been milled there on equipment that had been put into operation in 1929. With a sinking feeling, he knew that he was going to have to trace every shipment of wood to the McCormick Mill from the past 30 months. That odyssey, as Koehler described it, took him over 2,000 miles, visiting hundreds of mills, and examining thousands of boards, until he actually found a match at the National Lumber & Millwork Company in the Bronx, New York. The match only happened because the foreman remembered he had built a bin out of some McCormick Mill wood, and when he cut off the end of a beam, Koehler's ladder pattern matched perfectly.

Koehler believed that he was just one step away from connecting the wood with the person who had purchased it, but the mill owner gave him the fateful news that he only dealt in cash — there were no receipts. It was now November 29, 1933. With a sinking feeling, Koehler knew that he was going to have to start over, trying to trace the origins of the other three types of wood from the ladder. Koehler was consoled by the fact that, out of the entire eastern part of the United States, he had narrowed the search for the ladder's owner to the Bronx, which was the same place where the kidnapper had negotiated for ransom money.

Koehler started to work immediately on identifying where the other woods from the ladder had been milled. During the previous months, while Koehler had been following leads from mill to mill, law enforcement officials had been negotiating with the kidnapper's demands for ransom money. They had left $50,000 at a Bronx cemetery, following the instructions from a hand-written letter, but the body of the Lindbergh baby was ultimately found just a few miles from the Lindbergh home. The investigation to find the kidnapper continued for nearly two more years, until early 1934, when bills from the ransom money began turning up in the Bronx and Manhattan. The money had actually consisted of gold certificates, which by April 1933 was no longer legal tender, and members of the public were encouraged to report anyone who used it. After a gas station attendant reported the license plate number of a man who paid with a gold certificate, police arrested Bruno Richard Hauptmann, a carpenter who lived in the Bronx, 10 blocks from the National Lumber & Millwork Company, and less than 4 miles from the cemetery where the ransom money had been exchanged. Some $14,600 of the ransom money was found inside Hauptmann's house [3].

Koehler was now summoned to Hauptmann's house. One of the investigating officers had noticed that a floorboard had been sawed off in the attic and the police wanted Koehler to examine it. He brought Rail 16 with him, and the four nail holes matched up perfectly to the nails holes cut in the floorboard. The wood grains also matched perfectly (**Figure 3**). Later, when Koehler was able to examine the hand tools confiscated from Hauptmann's house, he was able to determine that the imperfections in the tool blades made cuts in wood identical to those on the ladder.

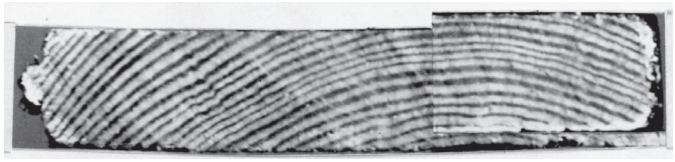

Figure 3. Cross-section of Hauptmann's floorboard and Rail 16 (Courtesy of USDA Forest Products Laboratory: Madison, WI; Forest History Society: Durham, NC).

When the trial of Bruno Hauptmann began, and Koehler was called to the witness stand, Hauptmann's attorney opened with the following declaration:

> "*We say that there is no such animal known among men as an expert on wood; that it is not a science that has been recognized by the courts; that it is not in a class with handwriting experts, with fingerprint experts or with ballistic experts," and later added "this is just merely a man who has had a lot of experience in examining trees, who knows the barks on trees and a few things like that*." [2]

But Koehler was more prepared, precise, and convincing than anyone else during the course of the trial. He presented charts, diagrams, photographs, and even attached a vise to the judge's desk, clamped in a board, sawed it off, and used the corresponding grain patterns to demonstrate a perfect match and how Rail 16 also matched perfectly to Hauptmann's floorboard. The thoroughness of Koehler's testimony and the dramatic nature of the evidence that he presented was heralded in hundreds of newspaper articles from coast to coast. The ladder itself became such a symbol of the trial that small white wooden replicas of the ladder were sold outside the New Jersey courthouse as souvenirs. And the evidentiary value of the ladder, and especially Rail 16, was so important that many books were eventually written about it and Koehler, among them: *Hauptmann's Ladder, The Airman and the Carpenter*, and *The Sixteenth Rail: The Evidence, the Scientist, and the Lindbergh Kidnapping*. Although Hauptmann maintained his innocence until the day he was executed, and although his wife continued for many years to try and prove his innocence, a number of prominent forensic scientists [4, 5] have examined Koehler's work over the years and have always found it to not only be accurate and exacting but thoroughly excellent work.

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COMMENTARY

"Junk Science" and Reasonable Doubt*

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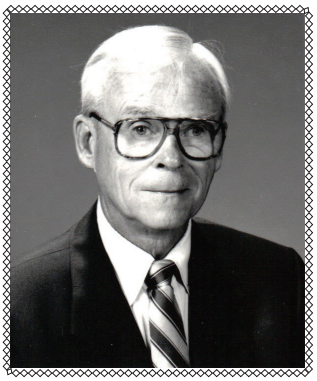

The author began his career in forensic science in 1957 and served actively in the Centre of Forensic Sciences (CFS) in Toronto, including 27 years as CFS laboratory director, until his retirement in 1994. He then served part-time as a private consultant on quality assurance and laboratory management issues until 2013. He is a past president of the Canadian Society of Forensic Science (CSFS), the American Academy of Forensic Sciences (AAFS), the International Association of Forensic Sciences (IAFS), and the American Society of Crime Laboratory Directors (ASCLD).

Following the 2009 publication of the National Research Council (NRC) report, "*Strengthening Forensic Science in the United States — A Path Forward*", and the 2016 report by the President's Council of Advisors on Science and Technology (PCAST), "*Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods*", we have seen constant reference in the media to forensic science — or at least some of its disciplines — as "junk science".

Some typical examples:

- "Junk Science at the FBI" (*New York Times*; April 27, 2015)
- "A Wake-up Call on the Junk Science Infesting Our Courtrooms" (*Washington Post*; September 20, 2016)
- *"*Jeff Sessions Is Keeping Junk Science in America's Courts*" (Rolling Stone*; May 9, 2016)
- "Is Forensic Ballistics 'Junk Science'?" (*Weapon Man*; May 9, 2016)

Both the NRC and PCAST Reports focused on methods for comparing bitemarks, latent fingerprints, firearms/toolmarks, footwear impressions, hair, and handwriting — what PCAST referred to as "feature-comparison" methods. It is important to understand that neither report concluded that these disciplines were invalid but rather that they simply had not been adequately validated — quite a different thing — a distinction not always recognized by the authors of the media articles.

Not surprisingly, neither report actually contained the term "junk science", which was first coined by Peter Huber in his 1991 book, *Galileo's Revenge — Junk Science in the Courtroom*, in which he described it thus:

> "*Junk science is the mirror image of real science, with much of the same form but none of the same substance*."
>
> "*It is a hodgepodge of biased data, spurious inferences, and logical legerdemain, patched together by researchers whose enthusiasm for discovery and diagnosis far outstrips their skill. It is a catalogue of every conceivable kind of error: data dredging, wishful thinking, truculent dogmatism, and, now and again, outright fraud*."

A damning indictment indeed! However, it doesn't sound like an accurate description of what is actually practiced in real forensic science laboratories on a daily basis.

The PCAST report describes validation as requiring that the methods:

> "be shown, based on empirical studies, to be repeatable, reproducible, and accurate, at levels that have been measured and are appropriate to the intended application." (my emphasis) p. 5

Okay. Let's consider what the "intended application" of forensic science is. In criminal cases (which are what most forensic science practitioners deal with) it is usually to assist in resolving some issue "beyond a reasonable doubt". That simple yet brilliant standard has been accepted in the criminal courts for more than three centuries. Thus, to meet this standard, validation would require that the methods be shown to be capable of producing results — not beyond any doubt but beyond a reasonable doubt — sometimes described as "an honest doubt of a reasonable person". So, when a latent print is compared

*An earlier version of this commentary was presented to *the 21st Triennial Meeting of the International Association of Forensic Sciences*; Toronto, Canada; August 21–25, 2017.

with a known print, or a fired bullet with one known to be fired from a specific firearm, or a questioned item of trace evidence with a known source sample, the purpose is not to determine whether they came from the same source to the exclusion of all other such sources in the world, but rather if they could have come from a population of such items that might reasonably be expected to have been at that location during a time frame relevant to the incident. The proper comparison population for a questioned glass sample from a burglar's glove is not all of the windows in town but only the broken ones. A bullet from a shooting in Toronto is not reasonably expected to have been fired from a rifle carried by a goat herder in the mountains of Nepal.

Thus, in forensic science validation of a method for its "*intended application*" may not need to be quite as challenging as some critics might suggest. None of us, however, would dispute that there are limitations in the number of peer-reviewed, published studies establishing the scientific bases of some of our disciplines or that more research to enhance knowledge about their validity and reliability is desirable. Actually, for most of our disciplines, mountains of potential validation data already exist; unfortunately, they are not readily available for external peer review or publication because they are in the training files of all the examiners who have gone through proper training programs or sometimes in transcripts of trials in which such evidence was challenged. Those examiners had to convince themselves and their supervisors through "empirical studies" that the methods they used do indeed produce results of the required reliability before they were ever allowed to apply them to a real case. The toughest test a result has to pass is not the one in the courtroom but rather the one it has to pass before it leaves the laboratory.

Many media articles contrast the validity of DNA profiling with that of other forensic science disciplines because the latter "originated in police labs" while the former came out of labs in academia. In fact, while the fundamental concepts and methods of DNA analysis were developed over many years in academia, the transition work to convert these into useful practical procedures for forensic science labs was largely performed in forensic science labs such as the FBI Lab, the Metropolitan London (Scotland Yard) Lab, labs in the UK Home Office, and others.

How different is that from the path that, for example, fingerprint identification followed on its way into law enforcement? In 1864, Dr. Nehemia Grew, a fellow of the Royal Society, noted "innumerable little ridges" on the ends of fingers. This was quickly confirmed by Marcello Malpighi, a professor of anatomy in the University of Bologna. Patterns formed by these ridges were described in 1823 by a physiologist, Jan Evangelista Purkinje of the University of Breslau. In 1877, Dr. Thomas Taylor**,** a microscopist with the US Department of Agriculture, suggested that "markings on the palms of the hands and the tips of the fingers" could be used for identification in criminal cases. This was confirmed by Dr. Henry Faulds, a Scottish physician, in a letter published in *Nature* in 1880 in which he described finger impressions in fragments of ancient pottery that he had used to eliminate an innocent suspect. This letter prompted publication of a letter from Sir William Herschel, an English magistrate working in India, reporting that he had been using thumb impressions to identify illiterate prisoners since 1856. He also made the critical observation that the patterns of what he called "papillary lines" did not change with time. Another who made important contributions was Sir Francis Galton, an English scientist whose research interests were the statistics of genetics and heredity.

None of these contributors to the fundamentals of fingerprint identification was employed by a police agency. Transition to a practical tool for identification began in 1892 in Argentina when Juan Vucetich, an anthropometrist working in a police office, used the identification of a bloody fingerprint to solve the murder of two small children. This transition continued with the work of Sir Edward Richard Henry, the inspector general of police in Bengal, India, in the 1890s, and was further enhanced in the early 1900s by Joseph A. Faurot, a detective sergeant with the New York City Police Department.

Thus, much like DNA profiling, the fundamentals of fingerprint identification were developed from academic pursuits but the transition to a practical tool for law enforcement was accomplished primarily, but not exclusively, in "police" labs.

Similar basic developments followed by transitional paths have been followed by most other forensic science methods. It should not be surprising that, after forensic scientists become aware of the potential application of some new developments, transition and continuing development are pursued largely by forensic scientists associated with law enforcement. They are, after all, the ones with the greatest interest. Such paths are followed by other professions or industries such as agriculture, mining, and pharmaceuticals.

Something we learn from working with the law is the importance of definitions to any attempt to bring understanding to an issue. There are many definitions of "science" but all consist of something like:

"Science" - knowledge of general facts, laws and relationships that is obtained through systematic observation and experiment, especially as applied to the physical world and the phenomena associated with it." (*The Canadian Encyclopedia*; McLelland and Stewart: Toronto, Canada; 1996)

One definition of junk is:

"Junk" — old or discarded articles that are considered useless or of little value. (*www.dictionary.com*)

If we accept such definitions, information obtained through "systematic observation and experiment" can hardly be considered "useless or of little value". "Science" and "junk" are thus mutually exclusive; if something is science, it cannot be junk. There can therefore be no such thing as "junk science".

In most of the media articles (or court transcripts) in which the term "junk science" appears, it is actually not "junk science" that is the concern but rather "junk testimony". For example, testimony about latent print examination having a "zero error rate" or that a bullet was fired from a specific weapon "to the exclusion of all other firearms in the world". Although such unjustifiable claims may no longer be made as often as they once were, a study published by Brandon Garrett and Peter Neufeld in the *Virginia Law Review* in March 2009 titled "Invalid Forensic Science Testimony and Wrongful Convictions" showed that such testimony has been more widespread than many of us believed.

The authors examined trial transcripts from 137 of 156 DNA exoneration cases and, in 82 (60%) of these, there was forensic science testimony which the authors described as "invalid". An important feature of this paper — and the reason it is cited here — is that it includes relevant portions of those transcripts so we can evaluate the testimony for ourselves. While one might argue that some of the testimony is not forensic science or challenge the categorization of some of it as being "invalid", the fact is that in many of the cases the testimony was quite shocking and came from 72 examiners in 52 labs from 25 states.

As might be expected, the majority of these cases were sexual assaults from the 1980s and early 1990s and involved ABO/PGM results or microscopic hair comparisons; i.e., they were the types of cases that retained items with the potential for the DNA evidence that eventually led to the exoneration. The commonest transgressions were failure to present potential exculpatory evidence, presenting improper population frequency numbers, and overstating the significance of hair comparisons.

I believe there are fewer examples of junk testimony today than there were in the 1980s and '90s. Accreditation and certification, with their requirements for enhanced training, improved documentation, and careful monitoring, deserve much credit for this. Nevertheless, such testimony undoubtedly still occurs. To deal with those media articles, we must continue to establish that the methods we use are indeed valid and strive to ensure that the testimony offered by forensic scientists is proper and appropriate.

Inadequate validation of methods can be dealt with by additional research and publication. Indeed, much has been done and continues to be done since the release of the NAS report in 2009.

However, junk testimony is more challenging because it often takes a random event for such a problem with an individual examiner or a particular laboratory to become public. Correction may require the challenging alteration of an institutional culture or an individual's attitude.

The transmutation of junk into gold is difficult but it can be done — and it is worth doing! We must continue to strive to do so.