Forensic Sci Rev 32:83–103
July 2020

Professional Review and Commentary[a]

M. R. Baylor (Editor)

Cary, North Carolina
United States of America

TABLE OF CONTENTS

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.

FORENSIC SCIENCE AROUND THE WORLD

The Practice of Forensic Science in Pakistan

Rana Muhammad Mateen*
Department of Life Science, School of Science
University of Management and Technology
Lahore, Punjab
Pakistan
+92 3338723480; mateenibb@yahoo.com

Asma Tarig
Institute of Biochemistry and Biotechnology
University of the Punjab
Lahore, Punjab
Pakistan

Besides other traditional crimes, Pakistan in the past has suffered from terrorist attacks and racist activism. The majority of investigations and analyses were conducted by the police, based on traditional investigation procedures. These procedures often led to the loss of precious evidence, or in most of the cases, contamination of the physical evidence. Due to increases in eyewitnesses' false statements, the judiciary system in Pakistan called for science-based investigation [1]. The need for modern ways of investigation has led to the establishment of forensic agencies in Pakistan.

Forensic Science Practices at the Provincial Level

The National Forensic Science Agency (NFSA), in Islamabad, was established in 2002 at the federal level. In the same year, Pakistan's first-ever DNA testing laboratory was established in the Center for Applied Molecular Biology (CAMB), in Lahore, for generating DNA profiles for comparison purposes [2,3]. For a successful case investigation, proper crime scene processing and proper evidence collection are mandatory. Crime scene units are now established at the divisional level in Pakistan's Punjab province. Personnel in crime scene units are well trained according to modern-day needs and techniques for successfully processing a crime scene. Besides crime scene processing, the Punjab province has a well-established laboratory, the Punjab Forensic Science Agency (PFSA), in the Lahore division. It is a state-of-the-art, fully functional laboratory having 14 specialized departments under one roof. Despite several critical limitations, such as low resources and a rising backlog of cases, this laboratory has proved valuable for solving several important cases. However, this laboratory is insufficient for a province of more than 100 million people, which calls for additional laboratories at the division level. In Khyber Pakhtunkhwa province of Pakistan, the Forensic Science Laboratory (FSL), in Peshawar, is providing assistance in crime scene investigation, evidence handling, chemical analysis, firearm, fingerprint, questioned documents, photography, and digital forensics. Moreover, a recently (2016) inaugurated FSL in the Swat district is also providing assistance in and around the Malakand division of Khyber Pakhtunkhwa [3,4]. In the Baluchistan province of Pakistan, the FSL in Quetta is performing casework mostly based on traditional techniques. Despite the approved act (the Baluchistan Forensic Science Agency Act of 2015) for the establishment of the forensic laboratory in Baluchistan province, no progress has been made in that regard [3,5]. In Sindh province of Pakistan, the Karachi police have a forensic investigation wing for evidence processing. In addition, the Sindh Forensic Science Agency, in Karachi, has been established in recent years at Karachi University. This laboratory has started functioning and it is performing casework on DNA and serology-based testing. Moreover, in Jamshoro, Sindh, another facility is available for DNA and serology-based testing [3,6].

Operations of Forensic Laboratories in Pakistan

Since beginning work in 2012, the PFSA has solved 248,000 cases involving different types of incidences. The PFSA not only receives cases nationwide but also from other parts of the world [7,8]. Meanwhile the NFSA, despite being established in 2002, has solved only 2,540 cases. FSL Peshawar in Khyber Pakhtunkhwa province has solved 40,000 cases since its establishment; however, most of these cases were solved using old techniques. The Sindh police have a separate forensic investigation division, which was established in 2009, and since then it has solved 50,000 cases. As stated earlier, no significant forensic science laboratory is available in Baluchistan province and most of the cases received in this province are solved using traditional techniques of investigations. The large population of Pakistan calls for the establishment of new forensic laboratories and capacity building of the existing forensic laboratories as well. Moreover, qualified and trained forensic experts are prerequisite for successfully solving a case.

References

1. Mateen RM, Tariq A: Crime scene investigation in Pakistan: A perspective; *Forensic Sci Int Synergy* 1:285; 2019.
2. Forensic DNA typing in Center for Applied Molecular Biology, Lahore; *http://www.camb.edu.pk/DNAlab.html* (Accessed February 11, 2020).
3. Mateen RM, Tariq A, Rasool N: Forensic science in Pakistan; Present and future; *Egypt J Forensic Sci* 8:45; 2018.

4. Kyber Pakhtunkwa forensic laboratory; *https://www.kpfsl.gov.pk/content&id=125* (Accessed February 10, 2020).
5. Baluchistan police forensic science laboratory; *http://www.balochistanpolice.gov.pk/sdev* (Accessed February 10, 2020).
6. Sindh police forensic investigation division; *http://www.sindhpolice.gov.pk/quickmenus/forinsic_division.html* (Accessed February 10, 2020).
7. Accessing forensic science landscape in Pakistan; *http://www.technologyreview.pk/assessing-forensic-science-landscape-pakistan/* (Accessed February 10, 2020).
8. Mateen RM, Tariq A: Increasing acceptability of forensic DNA analysis in Pakistan; *Egypt J Forensic Sci* 9:53; 2019.

Identifying Migration Fatalities Along the Greek Side of the Evros River Bordering Greece and Turkey

Pavlos Pavlidis*, Maria-Valeria Karakasi
Laboratory of Forensic Sciences
School of Medicine
Democritus University of Thrace
Dragana, Alexandroupolis, Evros Prefecture
Greece
+30 25513 53822; pavlidi@med.duth.gr

The regional unit of Evros in northern Greece (geographical area of Thrace) is considered the main gateway from the East to European territory. The area's Evros River is a natural boundary along the Greek border with Turkey and is the last major obstacle to be overcome before entering the Schengen area for hundreds of thousands of migrants following the eastern Mediterranean route. This river sadly is often deadly for thousands who attempt to pass illegally into Greece, and thus into the European Union [1].

Determining the identity of a corpse is an intricate and complex issue in forensic science. The classic methods of human identification (photography, fingerprinting, recording data for anthropometric characteristics, anatomical peculiarities or malformations, circumcision, surgical incisions, tattoos) are sufficient in cadavers that are within the fresh stage. In cadavers having undergone extensive putrefaction, however, human identification can get very complicated, while there are instances when it can actually become impossible. The latter often applies to deceased migrants who drown in their attempts to illegally cross the land borders of Greece in order to make their way into the European Union.

Due to the muddy texture of the river also containing accumulated tree branches, corpses remain trapped within the liquid medium extensively, so that when they are eventually detected and retrieved from the water, in the majority of cases they are in advanced decay; often they also have multiple postmortem lesions due to tissue consumption by aquatic fauna [2]. Furthermore, the development of putrefaction gases in the cadaver, in combination with the humid environment, lead to the loosening of the clothing garment seams and frequently to their shredding, which exposes the corpse. Documents proving the identity or nationality of the deceased are almost always absent. In some cases only parts (remains) of the human body are retrieved [1].

Role of Academic Forensic Science Laboratory

All border-related deaths of Eastern Macedonia and Thrace, including the cadavers retrieved on the Greek side of the river/border, are allocated and transferred to the Laboratory of Forensic Sciences of Democritus University of Thrace in Alexandroupolis for postmortem forensic examination and autopsy (cadavers on the Turkish half of the river are retrieved by the Turkish authorities). Prof. Pavlos Pavlidis (the senior author of the present article), as the coroner and head of the laboratory in Alexandroupolis, has been in charge of all fatal border-related incidents in northeast Greece since 2000 [1,3–5].

The depersonalization of the facial features of the cadavers as a result of their heavily distorted condition upon retrieval, combined with the lack of databases of dental procedures and the fact that the origin of the deceased is associated with challenging prevailing sociopolitical and economic circumstances. These factors hinder the decedents' relatives in their search by rendering corpse identification particularly difficult and sometimes even impossible [6–9]. Frequently, fingerprinting as a method is also disqualified by the concomitant skin maceration leading to skin detachment. Biological samples for DNA testing (teeth, bone samples) are collected from every cadaver; however, DNA identification also requires biological material to be obtained from the relatives, which is often unavailable. Therefore, in the many cases with a dearth of premortem data, all effort is based on utilizing the only available postmortem findings, while the adaptability of the forensic practice is considered imperative in the application of appropriate methods that can lead to the identification of the deceased [1].

Methodology of Identification

The water-resistant personal belongings of the dead (metal or synthetic items such as jewelry, plastic cards, and belts) are a key element in the methodology of identification as, upon recognition through photographs, they can serve as an indicative link that can connect the deceased with their relatives even if they are abroad (*see* **Figure 1**). Any recognition of the personal belongings found on the deceased on the part of the relatives of missing individuals is an indication that DNA sampling should be obtained by the relatives and dispatched through the consular authorities. The identification is achieved after the positive results of the DNA testing and the personal items are transferred together with the deceased to his country of origin [10].

Figure 1. Water-resistant personal belonings found on the deceased are key elements for identification.

During the last 20 years, a total of 445 border-related deaths have been assessed, of which 203 (45.6%) were found within liquid medium (river) in advanced putrefaction; accidental drowning was the major cause of death ($p < 0.00001$) (*see* **Table 1**). Among the latter, 78 (38.4%) were identified and the deceased were rendered to their relatives, while in 44.9% of these cases (35 cases), personal items were the key factor that led to the detection of the decedents' relatives abroad, which in turn led to positive DNA matching for the final verification of their identification (*p*-value 0.20054). The remaining 43 cases (55.1%) were identified by: anatomical malformations or surgical incisions, 5 (6.4%); tattoos, 4 (5.1%); and clothing, documents, anthropometric characteristics, and information on death circumstances (place and time of occurrence), 34 (43.6%).

In 22 (62.9%) of the 35 cases identified through personal belongings, the decedents carried more than one metal object. In 37.1% of the cases (13 cases), the recognized item was a wrist watch, and in 10 cases (28.6%) the recognized items were rings (*p*-value 0.44726). Regarding anatomical localization of the personal belongings, in 15 cases (42.9%) the recognized item was found in the anatomical area of the decedents' upper extremities (*p*-value 0.0394; result significant at $p < 0.05$), and in 7 cases (20%) on the decedents' neck.

Concluding Comments

Migration fatalities are a major issue of global importance that, from a medical approach, relates closely to global health and mortality by involving massive deaths and results in the mobilization of health institutions, government agencies, and nongovernmental organizations with reference to the management of unidentified bodies as well as the identification and rendition of the deceased to their relatives [1]. The potential development of an official database wherein the relevant authorities of each state can provide postmortem data on unidentified decedents and give access to relatives searching for missing individuals is still under discussion due to issues pertaining to the supervision and safeguarding of personal data [10]. The retrieval and utilization of the decedents' personal belongings for this purpose, however, can be assistive to overcome the obstacles for identification and play the role of the connecting link between the deceased and their relatives. Showing the photographs of the personal belongings of the deceased, through official authorities, can be a method to share information while preserving the personal data of the deceased; their recognition can give direction to the investigations and provide a strong indication for the final identification of the deceased. Good cooperation with communication of information between medical examiners and the consulates of the different countries is of pivotal importance, while the role of international nongovernmental organizations is also significant in order to reach relatives.

Table 1. Causes of death (# & %) among Evros River fatalities — Jan. 2000 to March 2020 ($n = 445$)

Drowning	Hypothermia	Road accident	Trauma due to mine explosion	Pathological causes	Undetermined
203 (45.6%)	88 (19.8%)	54 (12.1%)	49 (11.0%)	36 (8.1%)	15 (3.4%)

References

1. Pavlidis P, Karakasi MV: Greek land borders and migration fatalities — Humanitarian disaster described from the standpoint of Evros; *Forensic Sci Int* 302:109875; 2019.
2. Pavlidis P, Karakasi MV: A retrospective statistical review of deaths owing to migration through the southeasternmost land borders of the European Union, Greece 2000–14; *Disasters* 43:459; 2019.
3. Trilling D: In Greece, a river holds tragedy for migrants; *Aljazeera*; 2014; *https://www.aljazeera.com/indepth/features/2014/06/greece-river-holds-tragedy-migrants-2014630828461621.html* (Accessed May 20, 2020).
4. Brian T, Laczko F: *Fatal Journeys, Vol 2: Identification and Tracing of Dead and Missing Migrants*; International Organization for Migration: Grand-Saconnex, Switzerland; p 11; 2016.
5. International Committee of the Red Cross (ICRC): *Tragedy at Evros: A Perilous River Crossing to Greece*; 2017; *https://www.icrc.org/en/document/tragedy-evros-perilous-river-crossing-greece* (Accessed May 20, 2020).
6. Bublil N, Kahana T, Shenfeld M, Freund M, Hiss J: [Identification of unknown cadavers — Multidisciplinary approach] (in Hebrew); *Harefuah* 152:587; 2013.
7. Weedn VW: Postmortem identifications of remains; *Clin Lab Med* 18:115; 1998.
8. Caplova Z, Obertova Z, Gibelli DM, Mazzarelli D, Fracasso T, Vanezis P, Sforza C, Cattaneo C: The reliability of facial recognition of deceased persons on photographs; *J Forensic Sci* 62:1286; 2017.
9. Hadi H, Wilkinson CM: The post-mortem resilience of facial creases and the possibility for use in identification of the dead; *Forensic Sci Int* 237:149.e1; 2014.
10. Cattaneo C, Porta D, De Angelis D, Gibelli D, Poppa P, Grandi M: Unidentified bodies and human remains: An Italian glimpse through a European problem; *Forensic Sci Int* 195:167.e1; 2010.

Forensic Science Educational Programs (VI) — Programs in the US[a,b]

Corianne A. Rarrick, Amanda M. Cetnarowski, Elizabeth A. Gardner*
Department of Criminal Justice
University of Alabama at Birmingham
Birmingham, Alabama
United States of America
+1 205 934 0668; eagard@uab.edu

Development of Forensic Science Programs in the US

Historically, academic forensic science (FS) programs in the United States tended to be relatively small and were embedded in a criminal justice, chemistry, or biology department. Graduates from an FS program in a criminal justice department would often be lacking in laboratory training. Forensic science programs in chemistry or biology departments were frequently the basic science degree with a few criminal justice courses thrown in. Then, in the early 2000s, interest in FS surged as TV crime dramas migrated from the courtroom to the crime scene. Many colleges and universities responded to student demand by adding FS degrees to their curriculums. However, there were no guidelines or standards in place for education in the forensic sciences. In fact, some state crime laboratories would not hire an applicant with a master of science in FS unless their undergraduate degree was in chemistry or biology.

In response to the proliferation of FS programs, the American Academy of Forensic Sciences established the Forensic Science Education Program Accreditation Commission (FEPAC) in 2002 [1]. Standards were developed based on the guidelines established by the Technical Working Group for Education and Training in Forensic Science (TWGED) and FEPAC began accrediting FS programs in 2004 [2]. Accreditation is available for bachelor's and master's degrees, but not PhD programs at this time. As of 2019, there are 50 accredited programs in 37 colleges and universities and one Canadian university. This number is unlikely to change in 2020.

In the US, virtually all colleges offer associate's and bachelor's degrees, while universities offer bachelor's, master's, and doctoral degrees. The Master of Science in Forensic Sciences is the terminal degree in the discipline, though several universities have recently initiated doctoral programs in FS. The degrees in forensic science offered by colleges and universities are, in descending order, doctoral (PhD), master of science (MS), master of arts (MA), bachelor of science (BS), bachelor of arts (BA), associate of science (AS), associate of applied science (AAS), associate of arts (AA). An MS or BS in forensic science offers more opportunities for employment than an MA or BA, respectively. An MS degree will often result in only a slight increase in starting salary over a BS degree, as the amount of training required before being certified to do casework will be the same, but an MS is often a requirement for promotion to higher positions in the laboratory. An AS is not likely to lead to a job directly, but the student can then transfer the credits into a BS program. Many colleges and universities also offer minors and certificates in FS. A minor usually consists of six courses, with at least two being at the junior or senior level. A minor in FS, in conjunction with a BS in chemistry or biology, will provide a small advantage for applications to forensic crime labs or MSFS programs. Certificates can be applied to annual training requirements for FS positions.

Searching for Forensic Science Programs for Inclusion in This List

The search for forensic science programs in the US was done online, using primarily the FEPAC list of accredited programs [3] and the CollegeSource® Online [4] Google search, Universities.com, [5] and forensicscolleges.com [6] as primary sources. The keyword "forensic" and the criterion "any degree" were used with CollegeSource. For other search engines or web pages, disciplines were combined with forensic in the search terms, e.g., forensic biology, forensic chemistry, forensic accounting, etc. This was sufficient to identify FS programs as well as forensic anthropology, nursing, pathology, digital, cyber, and others.

Once a college or university with one or more FS programs was identified, the university's web pages were accessed to confirm that the program was active. The site was searched to find the location, home department, program URL, contract information, degree name,

[a] Editor's note: *Forensic Science Review* has previously published a list of North American programs accredited by the Forensic Science Education Program Accreditation Commission (*Forensic Sci Rev* 27:7; 2015). An updated version of accredited programs in the US has been incorporated in the current list.

[b] Authors' note: A draft version of this report was sent to contacts of all programs (included in the list) for verification. We apologize for omissions (if any) during the compilation process and deeply appreciate thee more than 80 responses — mostly requesting minor revisions of entries.

degrees offered, and accrediting body for the institution. For universities and colleges with multiple programs in different departments, each department and its associated degrees is listed separately under the institutions entry. All levels from PhD to certificate programs have been included, as each level serves different FS communities. However, degrees that offer forensic courses as electives are not included.

Only FEPAC is listed for accredited FS programs. Part of FEPAC accreditation is documenting that the institution is accredited by a regional accreditation organization like the Southern Association of Colleges and Schools (SACS).

No attempt has been made to evaluate the quality of the FS programs listed below (**Table 1**). With the proliferation of FS programs since 2001, it is important for potential students to evaluate a degree program carefully before deciding to enroll.

References

1. Almirall JR, Furton KG: Trends in forensic science education: Expansion and increased accountability; *Anal Bioanal Chem* 376:1156; 2003.
2. [US] National Institute of Justice: *Education and Training in Forensic Science: A Guide for Forensic Science Laboratories, Educational Institutions, and Students*; US Department of Justice, Office of Justice Programs, National Institute of Justice: Washington, DC; 2004; *https://www.ncjrs.gov/pdffiles1/nij/203099.pdf* (Accessed January 7, 2020).
3. Forensic Science Education Programs Accreditation Commission (FEPAC): Accredited Universities; *http://www.fepac-edu.org/accredited-universities* (Accessed January 7, 2020).
4. College Source Online; *https://cso.collegesource.com/CSO_Search.aspx* (Accessed January 7, 2020).
5. Universities.com; *https://www.universities.com* (Accessed January 8, 2020).
6. Forensic Colleges and Universities; *https://www.forensicscolleges.com* (Accessed January 8, 2020).

Table 1. Forensic science educational programs in the US

State	Institution[a,b]; City, State; Department; URL	Contact information[c]	Program emphasis	Degrees[a,d]	Accred.[e]
AL	**University of Alabama, Birmingham** Birmingham, AL 35294				
	Department of Criminal Justice *https://www.uab.edu/cas/criminaljustice/graduate/msfs*	Elizabeth Gardner; (205) 934-0668; eagard@uab.edu	Forensic sci. Digital forensics	**MSFS**, minor BS	FEPAC
	School of Nursing *https://www.uab.edu/nursing/home/academics/masters/post-msn-subspecialty-options*	Pat Speck; (205) 934-6790; pmspeck@uab.edu	Forensic nursing	MSN	
	Department of Computer Science *https://www.uab.edu/cas/computerscience/graduate-programs/masters-programs/ms-cyber-security*	Nitesh Saxena; (205) 975-3432; saxena@uab.edu	Cyber security	MS	
AL	Alabama State University Montgomery, AL 36101 Physical Sciences Department *https://www.alasu.edu/cstem/physical-sciences/forensic-science-program*	Gulnaz Javan; (334) 604-8130; gjavan@alasu.edu	Forensic sci.	MSFS, BSFC, BSFB	SACS
AL	Jacksonville State University Jacksonville, AL 36265 Department of Criminal Justice & Forensic Investigation *http://www.jsu.edu/criminaljustice/undergrad-forensics.html*	Chris Haney; (256) 782-5516; whaney1@jsu.edu	Forensic invest.	BS	SACS
AR	University of Arkansas at Pine Bluff Pine Bluff, AR 71601 Department of Chemistry and Physics *https://www.uapb.edu/academics/school_of_arts_sciences/chemistry_physics/degree_programs.aspx*	Grant Wangila; (870) 575-8382; wangilag@uapb.edu	Forensic chem.	BS	HLC
AR	Phillips Community College, University of Arkansas Helena-West Helena, AR 72342 Division of Arts & Sciences *https://www.pccua.edu/academics/career_cluster/safety*	Robin Bryant; (870) 338-6474 (×1370); bryant@pccua.edu	Crime scene invest.	CTF	HLC
AR	Southern Arkansas University Magnolia, AR 71753 Biochemistry and Chemistry *https://web.saumag.edu/academics/program/chemistry-forensic-science/*	Tim Schroeder; (870) 235-4277; tsschroeder@saumag.edu	Forensic chem.	BS	HLC
AR	University of Arkansas Community College Batesville, AR 72503 Division of Business, Technology and Public Service *https://www.uaccb.edu/academics/academic-divisions/business-technology-public-service*	Tamara Griffin; (870) 612-2022; tamara.griffin@uaccb.edu	Crime scene invest.	AAS, CTF	HLC
AR	Northwest Arkansas Community College Bentonville, AR 72712 Criminal Justice *https://www.nwacc.edu/degreecertificates/default.aspx*	Jerry Rose; (479) 619-4344; jrose@nwacc.edu	Proficiency in forensic sci.	CTF	HLC

(Continued on p. 129)

Upcoming Events*

Digital Forensics Research Workshop USA 2020 (*https://dfrws.org/conferences/dfrws-usa-2020/*)

July 20–24, 2020 (Virtual on-line conference)

International Association of Chiefs of Police — Training Conference on Drugs, Alcohol, and Impaired Driving (*https://www.theiacp.org/DAIDconference*)

Aug. 6–8, 2020; Grand Hyatt
San Antonio, TX, US (As scheduled for now)

ISHI 2020: 31st International Symposium on Human Identification (*https://www.ishinews.com/*)

Sept. 14–17, 2020 (Exploring virtual symposium option)

2020 International Conference on Forensic Nursing Science and Practice (*https://www.forensicnurses.org/page/2020AnnualConference*)

Sept. 23–26, 2020 (Virtual conference)

The Association of Firearm and Tool Mark Examiners — 51st Annual Training Seminar (*https://afte.org/news/afte-2020-covid-19*)

Oct. 4–8, 2020; Renaissance Austin Hotel
Austin, TX, US (Rescheduled from May 2020)

SCIX 2020 — Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies (*https://scixconference.org/*)

Oct. 11–16, 2020 (Exploring options)

Northeastern Association of Forensic Scientists — Annual Conference (*https://www.neafs.org/neafs-annual-meeting*)

Oct. 14–17, 2020; Marriott Mystic Hotel & Spa
Mystic, CT, US (As originally scheduled)

International Association of Chiefs of Police — 127th Annual Training Conference and Exposition (*https://www.theiacpconference.org/*)

Oct. 17–20, 2020; Venue to be announced
New Orleans, LA, US (As originally scheduled)

Mid-Atlantic Association of Forensic Scientists — Annual Meeting (*https://www.maafs.org/annual-meeting*)

Nov. 10–13, 2020; The Marriott at City Center
Newport News, VA, US (Rescheduled from May 2020)

*Event dates are based on information made available as of June 1, 2020. Organizers are closely monitoring COVID-19 pandemic status and may reschdule or cancel the events hereby listed.

American Academy of Forensic Sciences — 73rd Annual Meeting (*https://www.aafs.org/*)

Feb. 15–20, 2021; George R. Brown Convention Center
Houston, TX, US (As originally scheduled)

PITTCON Conference and Expo (*https://pittcon.org/exposition/*)

March 6–10, 2021; Ernest N. Morial Convention Center
New Orleans, LA, US (As originally scheduled)

American Society of Crime Laboratory Directors — Annual Symposium (*https://www.ascld.org/ascld-annual-symposium/*)

April 11–15, 2021; The Westin Copley Place
Boston, MA, US (As originally scheduled)

Canadian Society of Forensic Science 2020 Conference (*https://www.csfs.ca/*)

May 2021 (exact date pending); Ontario Tech University
Oshawa, ON, Canada (Rescheduled from May 2020)

25th Symposium of the Australian and New Zealand Forensic Science Society; 22nd Triennial Meeting of the International Association of Forensic Sciences — Joint Meeting (*https://iafs2020.com.au/*)

May 15–21, 2021; International Convention Centre
Sydney, Australia (Rescheduled from Sept. 2020)

International Association for Identification — 105th Educational Conference (*https://www.theiai.org/*)

Aug. 1–7, 2021; Gaylord Opryland Resort
Nashville, TN, US (2020 conference cancelled)

IFDAT 2020: The 10th Annual International Forum for Drug & Alcohol Testing Conference (*https://www.ifdat.com/*)

Sept. 19–21, 2021; Hotel Pitter
Salzburg, Austria (Rescheduled from Sept. 2020)

Society of Forensic Toxicologists — Annual Meeting (*https://soft-tox.org/meeting*)

Sept. 26–Oct. 1, 2021; Venue to be announced
Nashville, TN, US (2020 conference cancelled)

Northwest Association of Forensic Scientists — Annual Conference (*http://nwafs.org/wordpress/fall-meeting/*)

Sept. 27–Oct. 1, 2021; Venue to be announced
Portland, OR, US (2020 conference cancelled)

International Association of Forensic Toxicologists (*https://tiaft2021.co.za/general-information/*)

Oct. 24–28, 2021; Venue to be announced
Cape Town, South Africa (Rescheduled from Oct. 2020)

ADVANCING THE PRACTICE OF FORENSIC SCIENCE IN THE US — UPDATE

"An Update on Strengthening Forensic Science in the United States: A Decade of Developments"

November 12, 2019
American Association for the Advancement of Science Headquarters
Washington, District of Columbia
United States of America

MEETING SUMMARY

Reviewed by **John M. Butler**
NIST Fellow & Special Assistant to the Director for Forensic Science
National Institute of Standards and Technology
United States of America
+1 301 975 4049; john.butler@nist.gov

On November 12, 2019, the American Association for the Advancement of Science (AAAS), the Innocence Project, and NIST, in collaboration with the National Academies of Science, Engineering and Medicine (NASEM), held a one-day conference, "*An Update on Strengthening Forensic Science in the United States: A Decade of Development*". The conference was held in commemoration of the 10th anniversary of the 2009 National Research Council (NRC) report, "*Strengthening Forensic Science in the United States: A Path Forward*".

The January 2020 issue (Vol. 32, No. 1; pp. 9–10) of *Forensic Science Review* provided an outline of topics, moderators, and speakers. As an attendee, speaker, and meeting organizer, I was invited to provide some further details on the meeting beyond the topics covered and who spoke.

This conference was designed to celebrate progress and to reflect on existing and emerging challenges in forensic science and its use in the criminal justice system. The meeting was planned and organized by representatives from AAAS, the Innocence Project, the NASEM, and NIST. Key individuals in this effort were **Deborah Runkle** (Senior Program Associate, Scientific Responsibility, Human Rights and Law Program, AAAS), **Glinda Cooper** (Director of Science and Research, Innocence Project), **Anne-Marie Mazza** (Senior Director, Committee on Science, Technology and Law, NASEM), and **Richard Cavanagh** (Director, Special Programs Office, NIST).

Keynote addresses by **Professor Thomas Albright** (The Salk Institute for Biological Studies) and **Dr. Linzi-Wilson Wilde** (The Australian National Institute of Forensic Science) provided valuable perspectives on the importance of forensic science and its place in the scientific enterprise in the US and in Australia/New Zealand. A historical perspective on activities in the field since 2009, which was given by me, **John Butler** (NIST), set the stage for the sessions that followed:

- Federal agencies performing or funding research activities;
- Breakthroughs in foundational research;
- Breakthroughs in laboratory management;
- Human factors/cognitive bias;
- Court activities; and
- Wrap-up with reflections on the meeting presentations and projections on future needs.

Approximately 200 people attended the one-day meeting with another 360 watching it online (see *https://www.aaas.org/forensic-conference/2019*). Networking opportunities abounded during lunch and a reception held following the meeting. All sessions are currently available in nine segments on YouTube[a] for anyone wishing to review presentations and remarks made by the 28 participating speakers and moderators. Henceforth, I include some personal notes and reflections from the conference.

In his opening keynote address, Tom Albright discussed pattern-matching problems in everyday life and the impact of uncertainty, bias, and confidence on the human brain as an instrument of measurement. He emphasized that empirical validity testing is important and illustrated how this could be done with ground-truth, same-source, and different-source comparisons and examining performance on receiver operating characteristic (ROC) curves.

In my talk, I discussed the value of a historical review by quoting Pearl Buck ("If you want to understand today, you have to search yesterday") and George Santayana ("Those who cannot remember the past are condemned to repeat it"). The 13 recommendations made in the 2009 NRC report[b] were described, and then I touched on additional reports issued such as the 2016 President's Council of Advisors on Science and Technology (PCAST) Report[c]

---

[a]*https://www.youtube.com/watch?v=_vhGM2JnDkk&list=PLY1zaOaaYKDtfH2gU4XpcusBTk8vogFKT&index=2.*

[b]*https://www.nap.edu/catalog/12589/strengthening-forensic-science-in-the-united-states-a-path-forward.*

and the 2017 AAAS gap analysis studies[d]. I covered congressional hearings and key meetings held over the decade following the 2009 NRC report along with some books and important research published as well as major activities conducted such as:

- The White House Subcommittee on Forensic Science (2009–2012);
- The National Commission on Forensic Science (2013–2017);
- The Organization of Scientific Area Committee for Forensic Science (2014–present); and
- The NIST Scientific Foundation Reviews (2017–present).

I used an animated slide with 71 clicks to illustrate activities in the field from 2009 to 2019. At the end of my presentation, I shared some 1932-vintage ideas for firearms identification, which have still not been fully met (*see* COMMENTARY on p. 101), and a 1936 perspective on the importance of having a greater knowledge of validity of the methods used in criminal investigations and that "law enforcement agencies must be certain of their limitations as well as of their merits". Although a lot of progress has been made over the years, many challenges have not yet been resolved!

Federal Agencies Performing or Funding Research Activities

Jonathan McGrath (Office of Investigative & Forensic Sciences, National Institute of Justice, NIJ) spoke on NIJ funding efforts over the past few years. There have been 371 grant projects awarded since 2011 and $20.3 million was provided in 2019 via 44 awards. These are limited funds compared to the needs of the community for both research and operational activities. A 200-page[e] "*Needs Assessment of Forensic Laboratories and Medical Examiner/Coroner Offices*" was published in early December 2019 with findings that "forensic laboratories nationwide would require an additional $640 million annually to reach an optimal balance of incoming laboratory requests and casework reported".

Rebecca Ferrell (Division of Behavioral and Cognitive Sciences, National Science Foundation, NSF) spoke about the broad mission of the NSF and efforts they have made in coordinating with NIJ. NSF has funded over $100 million since 2017 on projects related to forensic science. An industry/university cooperative research center (I/UCRC) program funded the Center for Advanced Research in Forensic Science (CARFS), which is led by researchers at Florida International University.

Robert Ramotowski (Forensic Science Program Manager, NIST) reviewed NIST forensic science activities[f] that center on performing intramural research in six focus areas and extramural research through funding a Center of Excellence, CSAFE[g], convening meetings to examine issues, partnering with the community to strengthen policies and practices with the Organization of Scientific Area Committees (OSAC)[h], and exploring scientific foundations.

Gene Peters (Unit Chief, Counterterrorism & Forensic Science Research, FBI Laboratory) noted that the FBI Laboratory has contributed 260 publications since 2010 and discussed growth in their efforts with 156 research projects spanning 1999 to 2009 and 285 projects from 2010 to 2019. They have conducted decisional analysis "black-box" studies in latent print, firearms, shoeprint, and handwriting examination to examine repeatability and reproducibility.

Breakthroughs in Foundational Research

JoAnn Buscalia (Counterterrorism & Forensic Science Research, FBI Laboratory) covered FBI efforts in latent print foundational research that began after the Brandon Mayfield Madrid fingerprint error in 2004. Following recommendations laid out in a 2006 publication[i], they have published 12 journal articles on their decision analysis studies beginning with a 2011 article[j] titled "Accuracy and Reliability of Forensic Latent Fingerprint Decisions". The 2016 PCAST report was complimentary of the FBI "black-box" studies, which are designed to measure overall system reliability, and "white-box" studies, which are designed to understand factors that influence examiners' decisions. In the initial 2011 black-box study, a 0.1% erroneous identification rate was observed (six false positives occurred among 4,083 comparisons of non-mated pairs). White-box studies have noted significant variation in feature markup decisions among examiners and eye-tracking studies have been performed. In addition, it was noted that no-

[c] *https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_forensic_science_report_final.pdf*.

[d] *https://www.aaas.org/resources/forensic-science-assessments-quality-and-gap-analysis*.

[e] *https://nij.ojp.gov/library/publications/report-congress-needs-assessment-forensic-laboratories-and-medical*.

[f] *https://www.nist.gov/topics/forensic-science*.

[g] *https://forensicstats.org/*.

[h] *https://www.nist.gov/topics/organization-scientific-area-committees-forensic-science*.

[i] *https://archives.fbi.gov/archives/about-us/lab/forensic-science-communications/fsc/jan2006/research/2006_01_research02.htm*.

[j] *https://www.pnas.org/content/pnas/108/19/7733.full.pdf/*.

value (inconclusive) decisions are usually not verified and that examiner skill varies substantially.

Robert M. Thompson (Special Programs Office, NIST) addressed difficulties in firearms examination including the existence of significant variability in marks observed from the same firearm as well as similarities in marks produced by different firearms and the fact that there is no consensus on how to express the weight of evidence. The 2016 PCAST report expressed a desire to see firearms examination move from subjective to more objective methods. NIST activities were discussed including 3D virtual comparison microscopy, a ballistics toolmark research database, and congruent matching cells research. It was suggested that computer-aided techniques will augment rather than replace examiners in the future.

In her afternoon keynote address, **Dr. Linzi Wilson-Wilde** shared the structure and activities of the Australia New Zealand National Institute of Forensic Science (NIFS). NIFS performs centralized proficiency test purchases for the forensic laboratories in Australia and New Zealand as well as education and training. Since 2016, their "Forensic Fundamentals" efforts have explored underpinning science considerations and claims in multiple forensic disciplines. A research and innovation roadmap correlates operational priorities with what is missing. A 2019 document entitled "*Empirical Study Design in Forensic Science*"[k] provides helpful guidance on how to create a well-designed study. She noted that academic researchers are not interested in basic validation work and advocated for a united pathway forward via a global collaborative effort of forensic laboratories. Expanded funding remains a significant requirement to accomplish what is needed going forward.

Breakthroughs in Laboratory Management

Linda Jackson (Laboratory Director, Virginia Department of Forensic Science) leads a system of four laboratories in her state that have been accredited since 1989 and have had a science advisory board since 2005. Their department does not report to law enforcement or to a prosecutor's office and has been highly participatory in the forensic science community including her service on the National Commission on Forensic Science. Changes in their laboratory reports between 2005 and 2019 were discussed. Who the customer is has transformed over the years, more details are provided in an effort to improve transparency, and their standard operating procedures and training and quality manuals are publicly available online, which has reduced the number of freedom-of-information requests made. Ongoing collaborative research is conducted with university scientists. Training is regularly provided to attorneys and judges, including review of a complicated case file to teach what information is available and where. They face the challenges of being an early adopter with new technology (she provided an example with DNA probabilistic genotyping software implementation) as well as difficult decisions with resource allocation given a finite budget and staff with a growing caseload.

Peter Stout (CEO and President, Houston Forensic Science Center) reviewed the recovery of Houston from being named the worst crime laboratory in the country by the *New York Times* in March 2003. Since 2012, the Houston Forensic Science Center operates as a local corporation under a nine-member board of directors with approximately 30,000 requests each year handled by a staff of about 200. He is an advocate for information transparency and their website[l] includes thousands of documents and over 500 incident/corrective action reports. In addition, blind proficiency testing is conducted. Being independent has enabled them to focus resources where they, the forensic scientists, think they are needed. He expressed appreciation for the chance to control the message with freedom to speak to the press, which may not be granted when laboratories are under police departments. There was also a discussion on guidelines for testimony and monitoring expert witnesses through regular observation or transcript review.

Human Factors/Cognitive Bias

Melissa Taylor (Special Programs Office, NIST) described several human factors projects at NIST, including working groups (covering previous activities with latent prints[m] and handwriting[n] analysis) and process mapping where efforts are trying to optimize interactions with people, processes, management systems, and equipment as well as interactions among humans and other elements of the system. She emphasized that before you can improve a process, you must understand it. A traditional approach to error prevention is to make rules, enforce these rules, and punish violators through firing, suspending, retraining, or counseling them. If this is the approach and attitude,

[k] *https://www.anzpaa.org.au/ArticleDocuments/220/Empirical%20Study%20Design%20In%20Forensic%20Science%20-%20A%20Guideline%20to%20Forensic%20Fundamentals.pdf.aspx*.

[l] *https://records.hfscdiscovery.org/*.

[m] *https://www.nist.gov/publications/latent-print-examination-and-human-factors-improving-practice-through-systems-approach*.

[n] *https://www.nist.gov/programs-projects/forensic-handwriting-examination-and-human-factors*.

then we cannot make lasting systematic changes under a "one and done" mentality where a single error can lead to loss of a career. Some lessons learned from human factors studies are that:

- Errors occur in all human endeavors;
- Drift happens;
- Error reporting is a critical aspect of a quality management system;
- Fear of punishment for performance errors inhibits error reporting; and
- Errors can be prevented by designing tasks and processes.

John Holloway (Executive Director, Quattrone Center, University of Pennsylvania Law School) discussed root cause analysis (RCA) and emphasized that effective systems use feedback loops to assess and review error. RCA serves as a learning tool to identify core causative factors and necessary process or system redesign. The Austin Police Department review process was covered following a 2016 shutdown for issues in DNA mixture interpretation. It was noted that if we ask questions differently, we might get different answers. Conducting a review with the perspective of multiple stakeholders can help reduce bias. Efforts need to be made to gather and agree upon contributing factors, and conclusions should be published without trying to embarrass the participants. In effect, forensic laboratory analysts are like a quarterback that throws an interception. An effort must be made to try and understand what the quarterback saw as the play was unfolding, and why the quarterback decided that specific pass would lead to a good outcome, so that we can help the quarterback to do better the next time for the overall success of the team involved.

Court Activities

Mark Larsen (Criminal Division, King County, WA, Prosecutor's Office) felt like not that much has really happened in the courts since 2009. He touched on DNA being introduced into court and efforts to litigate with new types of DNA evidence from probabilistic genotyping software. The need for understanding and presenting electronic evidence has increased with smart phones and computer data. He reflected on how criminal justice was being scrutinized today in careful ways and that it is good to think about our culture and how to improve. Prosecutors serve an important role as gatekeepers in bringing good evidence into the courtroom.

Julia Leighton (retired, DC Public Defender Service) noted that what progress has been made in forensic science has not been made because of the courts. She felt that the 2009 NRC report has not brought about needed changes but generated outrage from the forensic community and a "full-throttle" defense from the government. In her view, too few defense attorneys have read the 2009 NRC report, and there is a crisis in the indigent defense community made more complicated by discovery rules and the difficulty of finding appropriate defense experts. In an adversarial environment, players are evaluated by winning or losing. The overall weakness is that the courts don't have a background in science and most forensic examiners don't have a background in research.

Bridget McCormick (Chief Justice, Michigan Supreme Court) concurred that very little has happened in the courts over the past decade in terms of addressing forensic science issues. She noted that 95% of criminal cases are in state courts and that in many jurisdictions, judges are elected. In addition, lawyers may be afraid of science. Solutions to needed improvements in forensic science will not come from litigation. She commented that money impacts activities and efforts and therefore admissibility challenges are more likely to occur in civil cases rather than criminal ones. The criminal justice system as a whole has not asked for changes in forensic laboratories and therefore there are lots of piecemeal efforts rather than a concerted effort for improvements. There was some discussion about the need for a more sophisticated gatekeeper to forensic evidence, but because of court limitations it was emphasized that forensic science needs to fix itself.

Reflections on the Meeting Presentations and Projections on Future Needs

The wrap-up session was moderated by **Glinda Cooper** (Innocence Project) with **Richard Cavanagh** (NIST), **Peter Neufeld** (Innocence Project), and **Jessica Wyndam** (AAAS) providing their observations from points made at the meeting and their thoughts on where future efforts might go. It was noted that efforts to improve and strengthen forensic science will take time and require funding for validation. There will be more digital evidence in the future, and growth in machine-learning (artificial intelligence) methods could lead to more computer scientists entering forensic science in the future. Due to observed variability with skills across laboratories, more training is needed. Upstream changes and fixes are needed before something goes to court (i.e., the scientists need to get the evidence right before the case comes to court). We have seen an effort to be more involved in forensic science by those doing basic research, which is a cause for hopefulness. It was agreed that there has been important progress over the past decade, but that we have a long way to go before we are where we need to be.

In Glowing Colors: Seeing the Spread of Drug Particles in a Forensic Lab

Rich Press
National Institute of Standards and Technology
Gaithersburg, Maryland
United States of America
+1 301 975 0501; richard.press@nist.gov

Two scientists from the National Institute of Standards and Technology (NIST) brought black lights and glow powder into the Maryland State Police crime lab to study the way drug particles get spread around crime labs when analysts test suspected drug evidence. Their study, recently published in *Forensic Chemistry*[a], addresses safety concerns in an age of superpotent synthetic drugs like fentanyl, which can potentially be hazardous to chemists who handle them frequently.

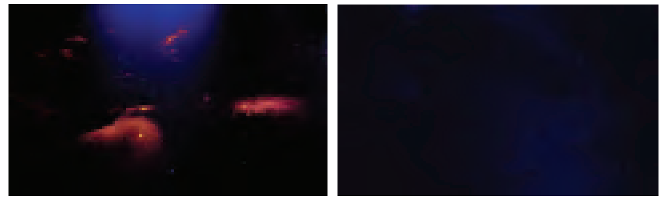
The spread of drug particles cannot be completely avoided — it is an inevitable result of the forensic analyses that crime labs must perform. To see how it happens, the two NIST research scientists, Edward Sisco and Matthew Staymates, fabricated a brick made of white flour mixed with a small amount of fluorescent powder. Under everyday lights the brick looked like evidence from a drug seizure, but under ultraviolet light — also called UV or black light — it glowed a bright orange (**Figure 1**).

Figure 1. Fabricated brick made of white flour mixed with a small amount of fluorescent powder under UV light (Credit: E. Sisco, M. Staymates/NIST).

Amber Burns, supervisor of the Maryland State Police forensic chemistry lab and a co-author of the study, examined the brick and its contents as she would real evidence. With a sheet of butcher paper covering her workspace, she cut open the package with a scalpel, scooped out a sample, and transferred that scoop into a glass vial for analysis.

She also removed the powder to weigh it on a digital scale without the packaging. When she was done, the black light revealed that some particles had settled onto surfaces in her workspace (**Figire 2a**). Some had also adhered to her gloves (**Figure 3a**) and were transferred by touch onto a marker and wash bottle (**Figure 3b**).

All chemists clean their workspaces between cases to prevent evidence from one case from contaminating the next. After Burns discarded the butcher paper and cleaned her workspace, the black light showed that her clean-up routine was effective (**Figure 2b**).



a b

Figure 2. UV light reveals some particles settled onto workplace surface (a) and effective cleaning (b) (Credit: E. Sisco, M. Staymates/NIST).

a b

Figure 3. UV light reveals some particles adhered to the gloves (a) and transferred by touch onto a scalpel (a) and wash bottle (b) (Credit: E. Sisco, M. Staymates/NIST).

Before the emergence of fentanyl and other superpotent drugs, such small amounts of drug residue were not a major concern. But that has changed, and not only for reasons of workplace safety. Drug dealers often mix small amounts of fentanyl into heroin and cocaine, and some labs are increasing the sensitivity of their instruments to detect those small amounts. Highly sensitive instruments are more likely to detect small amounts of drug residue in the environment, so those labs have to be extra careful about limiting their spread.

This visualization experiment led the authors to suggest several steps that might minimize spread, including:

- Changing gloves frequently;
- Using vials and test tubes with large mouths to limit spillage when transferring material into them; and
- Having two sets of wash bottles, one for casework and one for cleanup.

The researchers' paper[a] is written in such a way that any laboratory can reproduce the black-light experiment. "This is a great way for labs to see which of their practices contribute to the spread of drug residues, and to make sure that their clean-up routines are effective," Sisco said.

[a] Sisco E, Staymates ME, Burns A: An easy-to-implement approach for laboratories to visualize particle spread during the handling and analysis of drug evidence; *Forensic Chem* 18: 100232; 2020; *https://org/10.1016/j.forc.2020.100232*.

NEW BOOKS AND BOOK REVIEW

New Forensic Science Books

Alcohol, Drugs, and Impaired Driving: Forensic Science and Law Enforcement Issues

A. W. Jones, J. G. Mørland, R. H. Liu, Eds
CRC Press: Boca Raton, FL, US; 2020

Case Studies in Forensic Anthropology: Bonified Skeletons

H. M. Garvin, N. R. Langley
CRC Press: Boca Raton, FL, US; 2019

Detector Dogs and Scent Movement: How Weather, Terrain, and Vegetation Influence Search Strategies

T. Osterkamp
CRC Press: Boca Raton, FL, US; 2020

Disposition of Toxic Drugs and Chemicals in Man, 12th ed

R. C. Baselt
Baker & Taylor Publisher Services: Ashland, OH, US; 2020

Estimation of the Time Since Death: Current Research and Future Trends

J. Hayman, M. Oxenham, Eds
Academic Press/Elsevier: Waltham, MA, US; 2020

Essential Forensic Medicine

P. Vanezis
Wiley-Blackwell: Somerset, NJ, US; 2019

Ethical Standards in Forensic Science

H. Franck, D. Franck
CRC Press: Boca Raton, FL, US; 2020

Forensic DNA Profiling: A Practical Guide to Assigning Likelihood Ratios

J.-A. Bright, M. Coble
CRC Press: Boca Raton, FL, US; 2019

Forensic Engineering: The Art and Craft of a Failure Detective

C. Gagg
CRC Press: Boca Raton, FL, US; 2020

Forensic Entomology: The Utility of Arthropods in Legal Investigations, 3rd ed

J. H. Byrd, J. K. Tomberlin
CRC Press: Boca Raton, FL, US, 2020

Forensic Gait Analysis

H. D. Kelly
CRC Press: Boca Raton, FL, US; 2020

Forensic Science and Humanitarian Action: Interacting with the Dead and the Living

R. C. Parraor, S. C. Zapico, D. H. Ubelaker, Eds
Wiley-Blackwell: Somerset, NJ, US; 2020

GC-MS of Biologically and Environmentally Significant Organic Compounds — TMS Derivatives

V. A. Isidorov
John Wiley & Sons: Hoboken, NJ, US; 2020

Interpreting Complex Forensic DNA Evidence

J. M. Taupin
CRC Press: Boca Raton, FL, US; 2019

The Complete Guide to the ABC Molecular Biology Certification Exam

T. Roy, T. Price
CRC Press: Boca Raton, FL, US; 2020

Trends of Environmental Forensics in Pakistan

S. Iftikhar, Ed
Academic Press/Elsevier: Waltham, MA, US; 2019

Book Review

Chemical Warfare Agents, Biomedical and Psychological Effects, Medical Countermeasures, and Emergence Responses, 3rd ed

B. J. Lukey, J. A. Romano, Jr., H. Salem, Eds
CRC Press: Boca Raton, FL, US; 2019

Reviewed by

Robert M. White, Sr.
RMW Consulting, Inc.
Naples, Florida
United States of America
+1-239-776-1241; rmquail@comcast.net

This is the third edition of the book entitled, *Chemical Warfare Agents*, etc. making this series both up-to-date on key information and reorganized to address issues with the second edition. Through reorganization and the inclusion of both recent chemical warfare agent (CWA)/organophosphate incidents as well as improved detection and newer studies on CWAs, the third edition represents a mature volume in this series containing information that is current and well-organized. With restructuring of chapters from the second edition, creation of new chapters where information required revision, and the grouping of chapters into sections topics, information is better grouped and presented.

Chapters 1, 2, and 7 do an excellent job of presenting historical aspects of CWAs and chemical warfare up to modern times, including the use of chemical agents in the Syrian uprising and low-level exposure and its chronic effects from the Gulf War. Chapter 2 also addresses the basic chemistries of the CWAs. As is true for some other chapters, historical information, especially concerning the Syrian uprising, may be repeated. However, this serves to make a given chapter a stand-alone for purposes of separating out that chapter and presenting it to a group or individual whose main interest is focused on the given chapter. Chapter 3 provides an enhanced discussion of the toxicokinetics of nerve agents. Chapters 4, 5, 6, and 8 present organizations and/or programs designed to combat the use of CWAs and the results of some initiatives — especially those from the recent and still ongoing Syrian conflict.

Chapter 9, which discusses mustard vesicants, starts off Section II, titled “Agent Effects”. Chapter 10, “Health and Psychological Effects of Low-Level Exposure to Chemical Warfare Nerve Agents”, is an excellent presentation that addresses concerns raised by potential exposure of troops and civilians to CWAs, especially in the Gulf War. Chapter 11 addresses the important subject of “Inhalation Toxicology of Chemical Agents”. Chapter 12 is devoted entirely to the subject of cyanides and their toxicity toward different systems and the management of cyanide poisonings. Chapter 13 then focuses on ricin toxin, weaponization, inhalation, diagnosis of poisoning, detection, and experimental vaccines. Botulinum toxin (BoNT) is the entire subject of Chapter 14. The characteristics of BoNT intoxication as well as prophylaxis and treatment options for BoNT are presented. The broad class of incapacitating agents such as, but not limited to, capsicum, chloroacetophenone, and malodorants is addressed in Chapter 15. Chapter 16 closes out Section II and emphasizes screening smokes and their application, toxicology, and clinical considerations, as well as medical management.

Section III, “Protection”, is composed of Chapters 17–19. Chapter 17 is an updated review of the all-important subject of personal protective equipment (PPE) and is written by the author of the second edition. Chapter 18 provides an interesting perspective on the Food & Drug Administration’s approval of pyridostigmine bromide for protection against Soman (GD) and commentaries on prophylaxis for other organophosphates under the so-called “animal rule”. Chapter 19 introduces the concept of hormesis to the field of CWA defense. It is explained to be “a manifestation of ‘biological leveraging’ in which a stress or slight damage/toxicity is experienced in the expectation that it will induce a compensatory response sufficient to produce a net benefit that more than covers the biological costs of the initial stress/damage”. Although short, Chapter 19 is interesting reading about the application of an old concept to modern-day practice in CWA defense.

Section IV addresses the subject of detection, which may be of the most interest to analytical toxicologists. For the analytical toxicologist and anyone such as phlebotomists, nurses, or pathologists who may collect and handle biological specimens for subsequent analysis, Chapter 20 will be of interest for direct practical application. The remainder of the chapter focuses on individual assays for nerve agents, vesicants, cholinesterase activities, cyanide, phosgene, and the incapacitating agent 3-quinuclidinyl benzylate (BZ), and the strengths and weaknesses of each assay. Interesting follow-ups to Chapter 20 are Chapter 21, which is an extensive discussion of biomarkers for organophosphate poisoning; Chapter 22, which deals with field sensors that have to be employed if a laboratory analysis is not feasible due mostly to time constraints; Chapter 23, which speaks to the up-to-date topics of genomics, proteomics, and metabolomics applied to CWA defense; and Chapter 24, which discusses the emerging field of nanosensors. Chapter 21 includes advanced medical diagnostics such as magnetic resonance and positron emission tomography (PET). For those unacquainted with magnetic resonance and PET, ample background material is presented to familiarize the reader and allow them to apply the techniques to CWA damage. Also addressed in Chapter 21 is the use of a relatively new biomarker, microribonucleic acids (miRNAs). Chapter 21 concludes with a discussion on exhaled air biomarkers.

Section V, “Decontamination”, complements Section III (Protection). Section V has only two concisely written chapters. Chapter 25 discusses skin decontamination while Chapter 26 deals with the interesting subject of aircraft decontamination and mitigation.

Section VI, which includes Chapters 27–34, is, appropriately, an extensive section on “Treatment”. Chapter 27 presents a complete, practical overview of the treatment of military casualties, which should be of interest to anyone setting up or working in a field hospital where CWA casualties are likely to be treated. As a useful adjunct, Chapter 28 presents prehospital and hospital response to a mass casualty event. This chapter discusses the Israeli approach, which is presented from practical experience and should be quite useful to individuals who may be faced with a mass toxicological event. Chapter 30 also discusses medical management of CWAs. Chapters 29–32 address product research, protein scavengers of OP nerve agents, and research on oximes which may be used as reactivators. Chapter 33 looks into brain-penetrating reactivators of acetylcholinesterase (e.g., monoisonitrosoacetone, aldoximes, phenoxyalkyl pyridinium oximes), and Chapter 34 addresses seizures and *status epilepticus* precipitated by nerve agents.

The final section (VII) consists of Chapters 35–40, dealing with the subject of predictive modeling. Chapter 35 introduces computational modeling starting with the basics of chemical toxicity, including dose-response and probit transformations. Keying off a brief introductory statement concerning the number of both covered and uncovered animals used for testing, the chapter finishes with future directions including computational tools such as QSAR (quantitative structure activity relationship), EPI (estimation program interface) Suite™, VEGA (virtual models for evaluating the properties of chemicals within global architecture), and PBPK (physiologically based pharmacokinetic models). In this reviewer's experience, cell culture for such lofty goals as the prediction of which chemotherapeutic agent is best to treat a given patient's cancer have met with only marginal success overall. Chapters 36 ("Lung-on-a-Chip") and 37 ("Body-on-a-Chip for Pharmacology and Toxicology") are presented as three-dimensional alternatives that appear to have a more promising future. Chapters 38 ("Animal Models") and 39 ("Real-Time Physiological Data Collection and Analysis in Animal Inhalation Models: Predictive and Diagnosis Implications") present practical, useful information on the successes and failures of animal models with a further emphasis on the all-important inhalation route of exposure. The final chapter (Chapter 40) is short, but extremely important as it presents practical information on decision-making and what influences it.

Even though many of the topics are well-covered by detailed examination, this book reads easily and flows well with chapters that are arranged in an order designed to cover the subject of CWAs completely. Due to the number of abbreviations, a suggestion would be that a complete list of abbreviations for all chapters be included in one area of the book or available as an e-addendum even though some chapters (e.g., Chapter 5) have lists of their abbreviations at the ends of those chapters.

Without reservation, I highly recommend this book as an essential reference for not only clinical and forensic toxicologists, but also for warfare historians, first responders, emergency department personnel, individuals who work with related compounds such as organophosphate insecticides, industrial hygienists who treat organophosphate and other closely related exposures, pathologists, radiologists, and personnel who specialize in chemical warfare defense to include manufacturing and transport.

TEITELBAUM'S COLUMN ON FORENSIC SCIENCE — HISTORICAL PERSPECTIVE —

The Yule Bomber

Jeff Teitelbaum
Forensic Science Library Services
Washington State Patrol
Seattle, Washington
United States of America
+1 206 262 6027; Jeff.Teitelbaum@wsp.wa.gov

In 1922, before crime labs even existed in the US, and a full 10 years before the FBI was created, a Wisconsin prosecutor assembled an exceptionally innovative and comprehensive case in order to convict a man accused of mailing a homemade bomb through the US mail system. This case has been described as "*one of the most remarkable cases of scientific crime detection to be found in the law reports*" [1].

The early 1920s in the US was a fertile time for the development of criminal detection techniques based on scientific principles. Following the lead of Europe, and particularly of Edmond Locard, who in 1910 established the first modern scientific crime laboratory, many self-taught criminologists began incorporating chemistry, ballistics, photography, microscopy, and other technological tools in their efforts to solve crimes. Luke May, Edward Heinrich, and Calvin Goddard were a few of the early pioneers in the field of scientific criminal detection, but there were certainly no nationally recognized protocols or guidelines to follow either in criminal detection or criminal prosecution. And there definitely were no crime labs, especially in Wisconsin, which would not see its first state crime lab until 1947, so it was all the more remarkable that assistant attorney general Theodore Brazeau was able to conceive of and assemble a virtual army of scientists and evidence experts that completely overwhelmed the defense attorney in the case.

The Crime and Investigation

On December 27, 1922, in Marshfield (a town in Wood County, WI) James Chapman unwrapped a package that had been delivered to him. As soon as he cut the string that was glued around the brown paper wrapping, the package exploded, blowing off his left hand and sending shards of metal into the abdomen of his wife, who had been sitting next to him. She would die the following day.

Wood County Sheriff Walter Mueller arrived with his men within half an hour of the explosion and they were able to retrieve pieces of white elm wood, a metal trigger, an iron gas pipe, some brass tubing, and perhaps the most striking piece of evidence, portions of the brown wrapping paper with handwriting still visible. The package had been addressed to James Chapman, although the town Marshfield was misspelled *Marsfilld*. The postmark indicated the package had been mailed through a local post office.

Three lines of inquiry led to the arrest of a suspect, John Magnuson (**Figure 1**), a Swedish-American farmer who lived 7 miles from Chapman:

1. Looking for a motive for the bombing, Sheriff Mueller knew that Chapman had enemies, particularly Magnuson, who bitterly opposed a drainage ditch project that Chapman was heading. The previous summer, a large dredge brought in to begin digging the ditch had been destroyed by explosives.
2. A Swedish language expert, Prof. J. H. Stromberg at the University of Minnesota, concluded that the spelling of Marshfield as Marsfilld was written by someone whose original language was Swedish. It was a Swedish characteristic to write “mars” for “marsh” and “filld” for “field”. Magnuson was the only Swedish-American living in Wood County.
3. Chemist John Swenehart, a professor from the University of Wisconsin, said that the fumes and black smoke resulting from the explosion at the Chapman house probably came from picric acid and not dynamite. The county agricultural agent provided a list of farmers who ordered picric acid, usually for removing stumps, and the list included only one name whose address was in the drainage project zone: John Magnuson [2].

The Trial: Expert Witnesses and Court Documents

Magnuson was arrested on December 30, three days after the bombing, and his trial began less than three months later, on March 23, 1923. By then, prosecuting attorney Brazeau had assembled the following expert witnesses [3]:

Figure 1. John Magnuson [*Marshfield News-Herald*; May 12, 1925; public domain].

- **Arthur Koehler**[a] (University of Wisconsin professor and scientist at the US Forest Products Laboratory at Madison) testified that wood shavings found beneath a lathe on Magnuson’s farm were white elm, which was the same kind of wood used to make the block that encased the bomb. This was significant because the defendant claimed to have worked with oak but had actually denied that he had ever worked with elm wood in his shop. In fact, Koehler testified that the elm used in the bomb and the elm shavings from Magnuson’s workshop actually came from the exact same tree.
- **John Swenehart** (professor of chemistry at the University of Wisconsin) concluded that the explosive in the bomb was either TNT or picric acid because of the fumes and black smoke. He also testified that the steel trigger used in the bomb matched the metal from a gas engine on the defendant’s farm.
- **David Fahlberg** (professor of engineering at the University of Wisconsin) confirmed (along with John Swenehart, above) that the steel from a gas engine on the suspect’s farm was identical to the steel that was used in the bomb trigger. Under microcopic examination, he said that the two pieces matched in the thickness and size of minute crystals.
- **J. H. Mathews** (professor of chemistry at the University of Wisconsin) determined, through the use of photomicrographs and other techniques, that there were indisputable similarities between the metal used in the construction of the bomb and metal pipe found on the defendant’s farm.
- **Francis S. DuPont** (chemist from the Industrial Chemical Institute, Milwaukee) was requested to examine the ink used on the wrapping paper. He determined that it was a peculiar ink — a mixture of two inks. He then analyzed the ink at the Magnuson farm but it did not produce the same chemical reaction. It was discovered that Magnuson’s daughter, Ethel, had a pen that she had filled at home but later had refilled with ink at her school. Analysis of her pen ink exactly matched the unique mixture that DuPont had

[a] Arthur Koehler would later in his career be a key expert witness in connecting Bruno Hauptmann with the Lindbergh baby kidnapping.

found on the wrapping paper. Additionally, microscopic examination of the writing on the package revealed that it had been written with a fountain pen with a round point, which also matched exactly to Ethel's pen.

The glue that was used to secure the string on the package was also analyzed and was determined to be a brand named LePage. It was also confirmed that Magnuson used LePage's glue in an attempt to repair a fountain pen for his son.

- **Albert S. Osborn** (author of "*Questioned Documents*" and often called the "father of handwriting experts"), **John F. Tyrrell** (handwriting expert, Northwestern Mutual Life Insurance, Milwaukee), and **Jay F. Wood** (handwriting expert, Chicago) — perhaps the most preeminent handwriting experts in the US — worked separately and concluded that the handwriting samples of Magnuson matched the writing on the package. It probably did not help Magnuson's case that, while providing writing samples, he misspelled Marshfield as Marsfild, similar to the spelling on the bomb package.

  They also testified that the writing on the wrapper matched the characteristics of a pen used by Magnuson's daughter (**Figure 2**).

Here is a selection from court documents describing the construction of the bomb and Magnuson's farm [4]:

From the pieces picked up about the Chapman home the bomb was reconstructed and was found to be made of a piece of white elm, about fourteen inches long and about an inch and a quarter square, with a hole bored through the center, in which was placed a wagon bolt inside of a spring, which could be compressed by pulling the bolt back. The contrivance was so arranged that when the bolt was pulled back and the spring compressed it could be held in place by a trigger, which trigger could be secured by tying down one end with a string. Around the bolt and inside of the elm piece was a round brass tube, in which the bolt moved backward and forward. At the end of the square elm piece was a short piece of gas pipe screwed onto the piece of elm and connected with another small collar made from a piece of gas pipe.

At the end of the bolt was fastened a small firing pin, and the firing pin was arranged so that, when the bolt was released by cutting the string that held the trigger, the firing pin would strike the cap of the U.M.C. Remington twelve-gauge shell. All the paper part of the shell was cut off. In contact with the U.M.C. shell was a detonating cap which was buried in the T.N.T. which filled the gas pipe, so that when the U.M.C. cap was fired it exploded the detonating cap and the T.N.T. Shortly after the explosion the defendant's premises were inspected and searched with his consent. Pieces of gas pipe, of brass tubing, and other materials were taken from his premises, including a bottle of ink from his home and sawdust and shavings from his work bench.

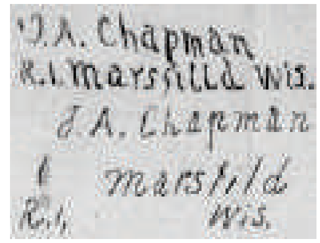
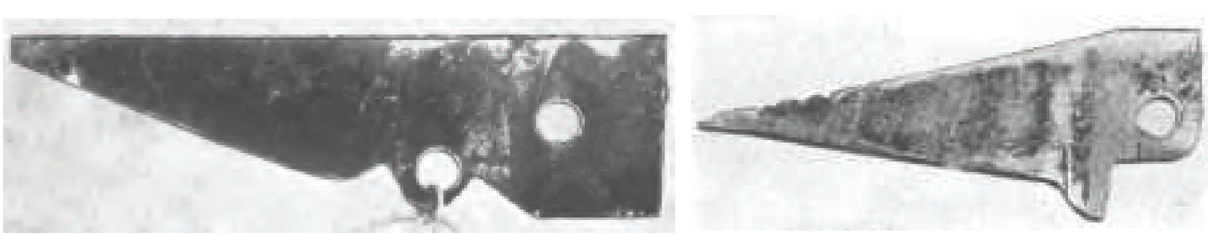


Figure 2. Handwriting on bomb wrapping (top) and writing sample of Magnuson (bottom) [*The Daily Tribune*; March 27, 1923; public domain].

There was found on the premises of the defendant a complete mechanical equipment for working in wood and iron, including a work bench, pipe wrench, monkey wrench, chisel, punches, planes, a thread cutter, drawing knife, hammer, blow-torch, files, hack-saw blades, emery wheel, and other tools, and there was found also a box containing T.N.T. and empty T.N.T. wrappers. There was also a lathe in the shop. T.N.T. detonating caps were found on the premises and No. 12 U.M.C. Remington shells, the same kind that were used in the bomb. A triangular trip or trigger was taken off the gasoline engine of the defendant on account of its resemblance to the trigger found on the bomb. There were also found springs and other miscellaneous articles, and an exploded shell which exactly corresponded with the shell found in the bomb was found on the work bench of the defendant. Search of Magnuson's farm turned up quantities of TNT as well as a number of U.M.C. Remington shells, the same type used in the bomb.

It is rather fortunate that a detailed report of the case was made by one of the expert witnesses, the chemistry professor J. H. Mathews, and so what follows is a section of his description of the metallographic analysis used in the examination of the bomb evidence [5]:

The first release mechanism, which is the smaller of the two pictures that we will see on the screen here in a moment [**Figure 3a**], *was taken from the bomb. And this one* [**Figure 3b**] *was taken from a gas engine. Those two perhaps do not look alike to some of you, but we found*



a b

Figure 3. Bomb trigger (a) and trigger from gas engine (b) at Magnuson farm [*Proc. Wisconsin Bar*; 1924; public domain].

upon examinations that the angles subtended between the two long sides were the same, within about a tenth of a degree; which would indicate that one of these pieces of mechanism had probably been used as a pattern for the other. Another thing which we noted was that when we calipered them with a very accurate micrometer, the thickness of the two mechanisms was found to be exactly the same, and was also the same as the thickness of some steel barrel hoops which were found upon the defendant's farm. Subsequent analysis showed that the material was of a quality of steel which is used in barrel hoops. We could not testify that it actually came from a barrel hoop. All we could say of course was that it was steel of that character.

So much for the simple physical tests, and the general appearance of the two release mechanisms. We come next to the metallographic examination. I was asked first whether it would be possible to tell by chemical analysis of these two pieces of steel, one taken from the bomb, the other taken from the farm, whether they were the same pieces of steel, whether they were identical; whether the material originally came from the same parent piece of steel. One cannot tell by a chemical analysis. Two pieces of steel might be exactly of the same chemical composition, and not be the same pieces of steel at all, of course. There are lots of pieces of steel that have the same chemical composition.

Another objection to a chemical analysis was the fact that if I used these triggers to make a chemical analysis, I would not have anything left to show in court; we would have to dissolve the material, and then the evidence would be gone, which would be unfortunate. Now there is a method of determining whether two pieces of steel or any two pieces of alloy are the same, or whether they are not, and that is by metallographic analysis. Metallographic analysis is really very simple. What we do is to polish a portion of the surface of the specimen, till we get a perfect polish. There must be no scratches present on the surface to be examined. Then we examine that surface with a high-power microscope and we see certain characteristics which will determine whether two pieces of steel are identical, or whether they are not. The examination is particularly conclusive if the polished surfaces have been etched. Steel is an alloy consisting of a mechanical mixture of various things; interlocking crystals. These crystals present different degrees of resistance to etching agents, such as nitric acid or picric acid, or a number of other things that might be used as etching agents. By putting the etching agent on the polished surface, leaving it twenty or thirty seconds, washing and drying it, and examining the surface, we find that the acid has acted unequally on different parts of the surface, because we have crystals of different substances. Some of the crystals are very resistant to the action of the acid; others are not; and the result is that we have a low-relief map showing the crystal structure right on the surface of the specimen [**Figure 4**].

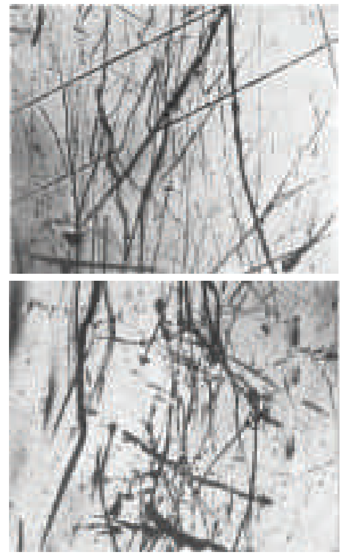


Figure 4. Photomicrograph of unetched surface of trigger used in bomb (upper) and trigger used on gas engine (lower) [*Proc. Wisconsin Bar*; 1924l public domain].

The trial of John Magnuson began on March 16, 1923, and on March 31, the jury found him guilty of murder in the first degree. Magnuson would spend 17 years in prison until he escaped in 1940, was arrested again in 1945 and finally paroled in 1952. He died in 1956.

There was not a single witness to connect Magnuson with the bombing, but Brazeau was able to overwhelmingly convince the jury with a case based entirely on circumstantial evidence. In an era where there was scant precedent for using science-based evidence in court, Brazeau essentially built his entire case on it. One other notable aspect of this trial was the use of metallographic analysis in connecting the material used in the bomb with the tools and equipment at Magnuson's farm. It is very possibly the first time metallographic analysis was used in a trial in the United States, and it is certainly the first time that a court recognized and accepted its inclusion as evidence.

References

1. Smith HW: Scientific proof and relation of laws and medicine; *Univ. Chicago L.R.*; 10:3; 1943.
2. How science sent Wisconsin man to prison for life; *Marshfield News-Herald*; February 5, 1935.
3. Balousek M: *50 Wisconsin Crimes of the Century*; Badger Books: Middleton, WI; 1997.
4. Magnuson v. State; Supreme Court of Wisconsin; 187 Wis. 122; 203 N.W. 749; 1925.
5. Mathews JH: The use of scientific methods in the detection of crime; *Wisconsin Bar Association Proceedings*; 116–123; 1924.

COMMENTARY

Decades of Developments in Forensic Science*

John M. Butler
NIST Fellow & Special Assistant to the Director for Forensic Science
National Institute of Standards and Technology
United States of America
+1 301 975 4049; john.butler@nist.gov

On November 12, 2019, at a special anniversary conference entitled "*Forensic Science: A Decade of Developments*" held at the American Association for the Advancement of Science (AAAS), I provided an overview of developments across the forensic science community in the decade following the 2009 National Research Council (NRC) report "*Strengthening Forensic Science in the United States: A Path Forward*" [1]. In the 20 minutes I had there — and in the short space here — it is impossible to provide more than a brief overview of activities across a very diverse and active community. Likewise, my meeting notes from this AAAS conference (*see* MEETING SUMMARY on p. 90) are limited, but hopefully will encourage interested readers to watch the full presentations that are available online (*https://www.aaas.org/forensic-conference/2019*).

Developments in the Past Decade

There have been numerous developments in forensic science in the past decade and over many years preceding the 2009 NRC report. In the US over the past decade, much of the activity at the federal government level has focused around three major efforts:

- A White House National Science Technology Council Subcommittee on Forensic Science that operated from 2009 to 2012;
- A National Commission on Forensic Science (NCFS), co-led by the Department of Justice and the National Institute of Standards and Technology (NIST), which operated from 2013 to 2017; and
- The Organization of Scientific Area Committees for Forensic Science (OSAC), which is administered by NIST and comprises more than 550 members from forensic disciplines across the community. OSAC, which began in 2014, has many ongoing efforts and activities[a]. I have written previously about these efforts in open-access articles published in 2015 and 2017 [2,3].

The author's career in forensic science began more than 25 years ago as a researcher in the FBI Laboratory's Forensic Science Research Unit, where he pioneered modern DNA testing techniques. Over his career (briefly in private industry and then for the past two decades at NIST), he has written 175 research articles and five textbooks on Forensic DNA typing and given hundreds of presentations across the US and in 27 other countries. In 2011, ScienceWatch.com *named him the #1 worldwide high-impact author in legal medicine and forensic science over the previous decade. He has been recognized for his professional contributions with the Presidential Early Career Award for Scientists and Engineers (2002), the Scientific Prize of the International Society for Forensic Genetics (ISFG) (2003), the US Department of Commerce Gold Medal (2008), the Paul L. Kirk Award from the American Academy of Forensic Sciences (AAFS) Criminalistics Section (2017), and the Legal Aid Society's Magnus Mukoro Award for Integrity in Forensic Science (2020). He has served as an associate editor for* Forensic Science International: Genetics *(2006–2019) and as a vice chair of the National Commission on Forensic Science (2013–2017); he is currently president of the ISFG, which has more than 1,300 members in 84 countries.*

In addition to these important US government efforts, there have been numerous books published, reports released, valuable research conducted, extensive media coverage at times, and a half dozen congressional hearings. And this is just in the US. The UK Forensic Science Regulator, the Australian New Zealand National Institute of Forensic

*These opinions, recommendations, findings, and conclusions do not necessarily reflect the views or policies of NIST or the US government.

[a]*https://www.nist.gov/topics/organization-scientific-area-committees-forensic-science*.

Science, and the European Network of Forensic Science Institutes have all been actively advancing forensic science in their regions of the world.

Numerous scientific societies exist, and dozens of meetings are held each year to provide opportunities for forensic scientists to share research progress and ideas, and to meet new people. These meetings enable communities to form and collaborations to commence. We in the forensic community learn from others who have gone before us. To paraphrase Isaac Newton, if we have seen further, it is by standing on the shoulders of giants[b].

But sometimes I wonder, how much progress have we made in past decades in addressing critical questions to forensic science? Are we even asking the right questions sometimes?[c] Technologies have advanced, such as the development of DNA testing or use of digital evidence, but perhaps we have not always fully addressed important concerns from the past.

Expertise Should be Demonstrated with Data: A Perspective from Nine Decades Ago

One of the giants whose shoulders I feel that I am standing on as a NIST researcher in forensic science is Dr. Wilmer Souder[d], who worked at my agency first as a physicist and dental materials expert, but over his productive career was involved in hundreds of criminal and civil cases[e] performing ballistics (firearms examination), handwriting, and typewriting identification from the 1920s to the 1950s.

In September 1932, Dr. Souder published an article that began:

> "Opinions on the science of firearm identification fall into two general groups. The first group would be represented by those who have no faith in the work and who condemn experts as absolutely unreliable and a menace to the State. The second group would be represented by those willing to grant that there are valuable results coming from such work when properly handled. It is to this second class of individuals that this paper is particularly directed. However, the first group should not be ignored. Perhaps they have more reasons for their skepticism than many of us have heretofore been willing to admit." [4]

Souder continues:

> "[expert] ability must be established by the correct solution of secretly prepared tests using more and more difficult combinations, locating the causes and amounts of individual variations of bullets from the same gun, and from different guns of the same make. The expert should work conscientiously in the field until he recognizes what can be done and what cannot be done. He should never hesitate to withhold weak or improperly supported opinions on the marginal or border line cases." [4]

In other words, Souder suggests that expertise in forensic science should be demonstrated with data — and that conclusions should not be given on marginal cases without an underpinning scientific foundation. These same points have been reiterated in recent years by reports from the National Academy of Sciences [1], the President's Council of Advisors on Science and Technology [5], and the American Association for the Advancement of Science [6,7].

Souder further notes:

> "Until satisfactory proof of expertness is required by the court, the untrained and the biased experts will be able to continue in 'business' and will continue to cloud rather than clarify cases." [4]

To prevent firearm identification (and other forensic disciplines) from being "retarded in [their] service to the administration of justice", Souder recommended that courts (and other stakeholders of forensic laboratories) should

> "be more correctly advised regarding the training and equipment necessary for such work, regarding the type of testimony and permanent records which should be required, and finally regarding limitations which must be observed in this as in all other sciences." [4]

Souder then proposes adoption of four standards to assist in strengthening forensic science [4]:

1. Minimum standards of equipment to be used;
2. Standards for records of evidence to accompany and substantiate the expert's opinion; there to include photographs, metrological data, and interpretations in permanent form;
3. Standards for qualification of experts that will include actual tests made against secretly designated materials and reported in compliance with item 2; and
4. Methods for constant following up of experts testifying in court to guarantee the highest efficiency.

---

[b] *https://en.wikiquote.org/wiki/Isaac_Newton*.

[c] See my keynote address at the Forensics@NIST 2018 meeting "Are We on the Right Side of the Equation?" available at *https://www.nist.gov/news-events/events/2018/11/forensics-nist-2018*.

[d] See article by Rich Press (2017) entitled "Who Was Detective X?" available at *https://www.nist.gov/featured-stories/who-was-detective-x*.

[e] Copies of Souder's notebooks are available in the NIST Digital Archive: *https://nistdigitalarchives.contentdm.oclc.org/digital/collection/p16009coll67/search*.

So how are we doing today with these proposed standards from nine decades ago?

OSAC is helping to prepare and promulgate documentary standards — yet minimum standards of equipment are not required currently in many forensic disciplines (DNA being a notable exception with the FBI Quality Assurance Standards[f]). Some aspects of records are covered by a commonly used accreditation standard (ISO/IEC 17025:2017), but detailed requirements for case report contents as well as data and records to substantiate an expert's opinion are still lacking. There is a growing effort to produce empirical data to support conclusions made by experts — and some forensic disciplines are further along than others.

Finally, more coordinated communication between forensic laboratories and the legal system to improve efficiency and methods to follow up on experts testifying in court can be improved. The creation of uniform language for testimony and reports (ULTRs)[g] by the Department of Justice is a step in the right direction.

A Call for More Science and Continued Improvement

With congressional funding, NIST is currently involved in several scientific foundation reviews[h] for the purpose of exploring what empirical data exist to support conclusions made by experts in various forensic disciplines. We are learning a great deal in conducting these reviews. The resulting reports will be made publicly available when the reviews are complete.

An article published in April 2018, entitled "A Call for More Science in Forensic Science" [8], which was written by six colleagues who served with me on the National Commission on Forensic Science, provides several key takeaways. They emphasized that:

- "DNA evidence and its success has changed our views and expectations of forensic science";
- "[F]orensic techniques [should] be subjected to independent validation before being introduced into common use"; and
- "[R]esearch and academic scientists should become educated about forensic science and take active steps to welcome the discipline into the larger scientific community."

[f]*https://www.fbi.gov/file-repository/quality-assurance-standards-for-forensic-dna-testing-laboratories.pdf/view*.

[g]*https://www.justice.gov/olp/uniform-language-testimony-and-reports*.

[h]*https://www.nist.gov/topics/forensic-science/scientific-foundation-reviews*.

To move the forensic science enterprise forward in a meaningful way in the coming decades, we need leadership, collaboration, and funding. As Michael Saks noted a decade ago [9], the field of forensic science would benefit from "honesty and humility" in carefully communicating what we know and what we do not know when reporting results from forensic evidence.

References

1. [US] National Research Council: *Strengthening Forensic Science in the United States: A Path Forward*; National Academies Press: Washington DC; 2019; *https://www.nap.edu/catalog/12589/strengthening-forensic-science-in-the-united-states-a-path-forward* (Accessed April 7, 2020).
2. Butler JM: U.S. initiatives to strengthen forensic science & international standards in forensic DNA; *Forensic Sci Int Genet* 18:4; 2015.
3. Butler JM: Recent activities in the United States involving the National Commission on Forensic Science and the Organization of Scientific Area Committees for Forensic Science; *Aust J Forensic Sci* 49:526; 2017.
4. Souder W: Precision measurements in firearm identification: Problems encountered in the art of identifying firearms; *Commercial Standards Monthly* 9(3):59; 1932.
5. [US] President's Council of Advisors on Science and Technology: *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods* (Report to the President; 2016); *https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_forensic_science_report_final.pdf* (Accessed April 7, 2020).
6. Almirall J, Arkes H, Lentini J, Mowrer F, Pawliszyn J: *Forensic Science Assessments — A Quality and Gap Analysis: Fire Investigation* (American Association for the Advancement of Science report; doi: 10.1126/srhrl.aag2872); July 2017; *https://www.aaas.org/resources/forensic-science-assessments-quality-and-gap-analysis* (Accessed April 7, 2020).
7. Thompson W, Black J, Jain A, Kadane J: *Forensic Science Assessments — A Quality and Gap Analysis: Latent Fingerprint Examination* (American Association for the Advancement of Science report; doi: 10.1126/srhrl.aag2874); September 2017; *https://www.aaas.org/resources/forensic-science-assessments-quality-and-gap-analysis* (Accessed April 7, 2020).
8. Bell S, Sah S, Albright TD, Gates SJ, Denton MB, Casadevall A: A call for more science in forensic science; *Proc Natl Acad Sci USA* 115: 4541; 2018.
9. Sake M: Forensic identification: From a faith-based "science" to a scientific science; *Forensic Sci Int* 201:14; 2010.