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

[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 in the UK. Part III: Regulation of Forensic Science in England and Wales — The Role of the Forensic Science Regulator —

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This is the third of a trilogy of articles reviewing forensic science provision in the UK [5,6]. Forensic science evidence plays a pivotal role in the resolution of many criminal cases, and how this evidence is processed and reported from crime scene to court is of paramount importance to the correct functioning of the criminal justice system (CJS).

There are three different CJSs in operation within the UK, one for England and Wales and separate systems for Northern Ireland and Scotland. Within these systems, forensic science services are provided by different organizations. In Scotland and Northern Ireland, services are publicly funded and provided by the Scottish Police Authority and Forensic Science Northern Ireland, respectively [6]. In England and Wales there is a competitive market that was created following the McFarland Review in 2002 [7]. This has evolved to the current fragmented market situation in which services are supplied mainly in-house by the 43 police forces (80%) with the remaining 20% of services provided by three main private companies (Eurofins Forensic Services, Key Forensic Services, and Cellmark Forensics, Inc.) along with a number of smaller companies. Such fragmentation of provision requires regulation and this is provided by the Forensic Science Regulator (FSR). This article describes the role of the FSR and looks at some of the issues that have emerged since the role was created.

The Forensic Science Regulator

Creation and Role of FSR. The system in England and Wales is unique in having a forensic science marketplace in which services, to both the prosecution and defense, are provided by both public and private providers. To ensure that such a diverse system of provision operates to the expected quality standards, the position of FSR was created by the Minister of State in 2007 [13]. Prior to this the Forensic Science Service (FSS) was largely responsible for setting standards and providing advice; however, with the FSS's closure in 2012, the role of the FSR became more critical because forensic science provision in England and Wales moved to a fully private market.

The FSR is a public appointment that operates on behalf of the CJS as a whole. The role is supported by the Home Office but it is independent, which allows recommendations and decisions to be unbiased. The first appointment of FSR (in 2008) was Mr. Andrew Rennison. The appointment is for three years with a possible extension for a further three years. This was the case for Mr. Rennison, whose term of office ended in 2014. His successor was Dr. Gillian Tully, appointed for three years in 2014 and since extended in 2017 until 2020.

The FSR role is defined on the website [4] as follows: "The Forensic Science Regulator ensures that the provision of forensic science services across the criminal justice system is subject to an appropriate regime of scientific quality standards." Expanding this further as a set of responsibilities gives the following:

- To identify new quality standards in forensic science activities not yet covered;
- To improve, where necessary, existing quality standards;
- To provide advice and guidance to help forensic science providers demonstrate compliance with the standards; and
- To investigate complaints and review performance of organizations working with forensic science evidence within the CJS.

The FSR is therefore tasked with developing, implementing, and maintaining quality standards. The standards are presented in the document *Codes of Practice and Conduct for Forensic Science Providers and Practitioners in the Criminal Justice System* [2]. The FSR also develops standards jointly with other organizations or adopts standards that have been developed by others. For example, the *Code of Practice for Forensic Anthropology* [2], published in May 2018, has been developed in association with the Royal Anthropological Institute and, also in 2018, the FSR adopted the standards for forensic toxicology produced by the United Kingdom and Ireland Association of Forensic Toxicologists. Version 1 of the codes of practice and conduct was published in 2011 and covered the period 2011–14. Since then four more versions have been published; the current version (Version 5) was issued in 2019 [2].

Codes of Practice. Initially the codes of practice were intended for implementation by providers of laboratory-based forensic science services;. However, Version 4 (issued in 2017) referred to "all those providing forensic science services to the Criminal Justice System" [2] as the current FSR aims; requirements were set out in 2016 requiring all forensic science disciplines, from crime scene to court, to be compliant with the quality standards. The codes specify the requirements of a management system to be able to demonstrate the ability of providers to deliver forensic science services that meet the requirements of the CJS and are intended to be used alongside other international standards. They are not intended to be used as a complete substitute for the international standard. In addition, the codes also give a timetable for implementation of both the code of practice and the relevant international standard by providers, whether public, police, or commercial, for the range of forensic science activities specified. For example, forensic toxicology compliance was required by October 2017 for both the code and ISO 17025; crime scene investigation compliance is not required until October 2020 for both the code and ISO 17020. Although separate codes of practice apply to forensic anthropology, forensic pathology, and forensic archaeology, regulation by the FSR still applies.

Appendices to the codes of practice provide further explanation of the requirements of the codes for specific areas such as bloodstain pattern analysis, DNA analysis, and digital forensic services. Guidance and advice documents are also provided in the appendix. For example, the document "*Method Validation in Digital Forensics*" [2] provides advice and guidance on the stages of validation and how validation can be carried out in digital forensic science.

The work of the FSR is supported by the Forensic Science Advisory Council (FSAC) whose role is to support and provide advice in areas such as the setting of standards and monitoring of compliance, validation and accreditation, international developments, and complaints from stakeholders. The FSR has also established specialist groups to advise and undertake studies in specific areas of forensic science. Currently there are six active specialist groups in areas such as digital forensics, DNA analysis, and quality standards. The groups comprise subject experts and representatives from other areas of forensic science and the CJS. When standards are developed, they go out for consultation and the feedback is reviewed by the specialist groups before the standards are finalized and published.

Implementation of Standards Through Accreditation. The FSR office keeps standards under constant review. The FSR's annual report [1] includes a review on the implementation of accreditation against the codes of practice. The FSR is provided with a snapshot of UK Accreditation Service (UKAS) findings from audits that is evaluated and disseminated through the annual report. If changes or updates to the standards are needed, these are brought in line on April 1 or October 1 each year with a 3-month period for implementation. The FSR also uses the annual report to signpost future changes or likely changes in the codes, so there is time to implement a transition.

The approach of the FSR for implementation of the standards is that providers achieve accreditation to the appropriate international standard that must include compliance with the requirements of the relevant code of practice. Laboratory-based activities have to be compliant with the international standard BS EN ISO/IEC 17025: 2005, *General Requirements for the Competence of Testing and Calibration Laboratories* (currently transitioning to the 2017 version) [10]. ISO 17025 only applies to laboratory testing and so providers of forensic science services at crime scenes have to demonstrate compliance with BS EN ISO/IEC 17020:2012, *General Criteria for the Operation of Various Types of Bodies Performing Inspection* [9]. The use of this standard is more evident in the FSR's timetable for implementation by 2020 as more crime scene activities are included.

Compliance with the standards can be monitored by the FSR through the system known as accreditation; however, this cannot be delivered across the sector by the FSR and the small team of scientists that constitute the FSR office. The FSR is therefore reliant on the UKAS, an independent organization, to accredit forensic science providers.

Accreditation and the UK Accreditation Service

Accreditation is the system that provides assurance that forensic science providers meet the relevant quality standards; it also provides confidence in the technical competence of providers to carry out specific forensic science activities. Accreditation is carried out by the UKAS which, by law, is appointed by the government as the national accreditation body. The accreditation process involves an assessment by UKAS assessors to establish that the provider is technically competent and has resources and facilities appropriate for the forensic science activity, and that the actual performance is carried out to the required standard. Accreditation is an ongoing business process and so the assessment also establishes that the provider is capable of sustaining the required level of performance. This is monitored by annual surveillance visits with reassessment every fourth year.

Most of the forensic activities covered by the codes of practice require accreditation to ISO 17025. This

is an international standard and gives a generic set of requirements to show that a laboratory operates a quality management system and that they are technically competent in the testing and calibration work that they carry out. The laboratory defines the scope by identifying the testing activities that it seeks accreditation for.

ISO 17025 covers two main types of requirements, management and technical. So, for example, a drug analysis laboratory that is accredited to provide results to an evidential standard will include, in the scope, a list of drugs covered by its testing procedures — or, if the drugs are new or rarely tested for, the lab will include a procedure for the testing of such substances. The technical requirements are focused on the use of validated methods and ongoing quality control that demonstrate that the laboratory is competent to carry out the testing and that the results are to the standard required at all times.

The importance of the accreditation process and the role of UKAS in discharging the responsibilities of the FSR cannot be overstated; however, a number of issues of concern were raised in the recent House of Lords report [8]. It was suggested that UKAS assessors often did not have forensic science experience and the codes of practice were not interpreted consistently. A requirement of the FSR is that all providers should be compliant with the standards; however, the FSR does not currently have the power to make this a mandatory requirement in order to practice. Currently there is market pressure for work to be given only to accredited providers and the three main commercial providers are all accredited, as are a number of others. However, this only covers about 20% of provision; 80% is conducted in-house by police forces, many of which are not accredited.

Another area of concern is accreditation of small businesses and sole traders that provide niche services. It is argued that the financial costs of the accreditation process make it very difficult for these providers to operate under such a regime. However, the FSR sees accreditation as the only way to ensure a level playing field for the quality of forensic science services across the CJS. The House of Lords report supports this and recommends that the FSR be given the necessary statutory powers [8].

Assuring the Competence of Practitioners

Some countries, such as the US, have a system of certifi-cation of practitioners to ensure the competence of individuals providing forensic science services within the legal system. Appropriate training of staff and assessment of competence is a requirement for accreditation, as is a program of continual reassessment. UKAS auditors include competency assessment in their site visits. Adverse judicial comments and complaints that could undermine an individual's credibility must be part of the reassessment of competency. However, England and Wales do not have a register of competent forensic science experts operating within the CJS.

In 1999 the Council for the Registration of Forensic Practitioners (CRFP) was established. The CRFP was set up to assure the courts that those on the register were competent forensic practitioners; however, the scheme only survived for 10 years and was closed in 2009. Throughout its duration, the scheme remained voluntary and practitioners, not on the register, were still able to practice and present evidence in court. It was also underfunded, with this being one reason why a registration scheme for individuals is still not proposed for England and Wales.

Accreditation does address the competence of staff but, as demonstrated by recent high-profile cases, substandard work by individuals can still appear in the system and possibly go undetected, ultimately leading to miscarriages of justice. This is recognized in the House of Lords report [8], which recommends that the FSR be given power to apply sanctions, up to debarment, to individuals found to have been presenting misleading or insufficiently evidenced opinion. The FSR should maintain a register of those practitioners debarred from presenting evidence in court.

Research and Development and the Role of the FSR

The FSR regularly expresses opinion on research and development through reports and written commentaries published in forensic journals. In the 2018 annual report [1] the FSR identifies, as medium priority, the need for quality-related research priorities to be articulated and funding applications supported in line with these priorities. These priorities are driven largely by the end users of the research (i.e., stakeholders in the CJS) and covers areas such as generating databases in transfer and persistence studies and developing robust methods of interpretation that focus on evidential value. These areas of research are not seen as sufficiently innovative and fall outside of the funding areas targeted by Research Councils. As the Research Excellence Framework also does not currently identify forensic science research as a unit of assessment, there is a funding challenge in developing research collaborations with universities.

Lack of funding for research across the sector is a major concern highlighted in the House of Lords report [8]. The commercial sector struggles to remain profitable and so limited funds, if any, are available to invest in research activities. The report recommends that the UK government increase funding for forensic science research and that UK Research and Innovation should establish a National Institute for Forensic Science.

Even if funding for research and development into new technologies were available, implementation by end users would be challenging in the current financial climate. Commercial providers, given the need to be profitable, are unlikely (and unable) to invest in any new technology and so current methods, based on old technology, are likely to be retained.

The Next Generation of Forensic Scientists

The FSR has expressed concern regarding the development of the next generation of forensic scientists. Training and investment are key in this area, in the FSR's opinion. Very recently she expressed in a commentary that cost-cutting poses risks for the development of the next generation and may even damage the present generation of forensic scientists [14]. Cost can hinder the implementation of more effective new methodology or the validation of new methodology because of the need for new instrumentation. If margins are too small the risk is to avoid implementing these methods. This can be a risk as there are new requirements. For example, in areas like drugs and toxicology where there are always new drugs coming along, laboratories will have to get their methods accredited. Research has to be developed as they must have a procedure for analyses that underlies drugs that are not yet on their scope of accreditation.

Under the view of the FSR is the idea that companies are interested in doing research, but money can be an issue. There is research coming from the commercial sector trying to fill this gap, especially from instrumentation companies developing new technologies. Also, universities have a role to play. Both need the indispensable role of the forensic science organizations to properly validate their work for forensic use because the technology developers understand technology and universities understand the science, but both do not have the practical experience and understanding of the challenges and inherent complications in forensic science.

International Collaboration

There is strong cooperation between the office of the FSR and different agencies in the US with fluid information and advice or even resources crossing the Atlantic in both directions. In the case of Europe, the FSR's team liaise and share information through a network of specialist groups in different areas, such as DNA, digital forensics, forensic pathology, medical forensics, and various other subgroups, including fingerprint comparison groups. Some of these contacts are directly with institutions, for example with The Netherlands Register of Court Experts.

There are also relationships with other international forensic bodies, for example in Australia, where the FSR regularly meets with the head of the standardization body in Australia. In the case of Australia, the FSR also chairs the British Standard Institute (BSI) Mirror Committee for forensic science. The BSI has mirrored committees with different countries and follows international standards development in a whole range of areas. The ISO Technical Committee ISO/TC 272 has recently published the first two standards in forensic science: ISO 21043-1:2018 [11] and ISO 21043-2:2018 [12]. So, through mirror committees the FSR provides input from the UK on those developing standards. On occasions where the standards being developed are at a lower level than those already in place in the UK, there is no synchronization. With the requirements of the new ISO standards in forensic science already covered in the codes then certification against these standards will not be required by the FSR.

The FSR's office also suggests development of standards at the international level. An example is the present lobbying for standards to regulate the quality of consumable items for use in forensic science. There are ISO standards for DNA and for DNA consumables but there is a need to establish guidance for other areas such as toxicology and fire investigation.

Miscarriages of Justice

Perhaps the ultimate test of the quality system set out by the FSR's requirements is the absence of "miscarriages of justice" arising from errors in forensic science evidence. Quality failings are referred to the FSR and rated according to their level of risk to the CJS. In recent years, there have been a number of high-risk incidents in which the evidence/results have been altered by individual employees. One well-published incident involved Randox Testing Services (RTS), a private forensic toxicology provider, in which casework results carried out for 42 police forces had been affected by data manipulation. RTS is accredited by UKAS for their testing procedures and so this demonstrates that accreditation does not necessarily assure the continued quality of forensic science evidence provided or ensure that quality failures are picked up early as more than 10,000 cases have been affected. The FSR is adding a data integrity audit to the codes to increase the chance of data manipulation being detected at an early stage.

In the most recent annual report the FSR raises issues with regard to lack of integrity [3]. Two types are identified: the first is lack of candor when producing reports and statements and the second is lack of understanding of the role and requirements imposed on those involved in the CJS. In order to address the latter, the FSR is producing

training material for use by providers. Learning from quality failures is the aim of a series of *Lessons Learnt* publications now being produced by the FSR. At the time of this writing, five publications are available.

The number of quality referrals to the regulator has increased steadily over the last four years [3]. This is not seen as a concern but, as the failings have been identified, viewed as a success of the increasing compliance with quality standards.

Conclusion

The FSR has been pivotal in enhancing the quality of forensic science provision in England and Wales to its current position, which sees a system of standards in place for many forensic science disciplines and many providers compliant with these standards through the process of accreditation. The FSR website [4] reveals the vast amount of work that has been carried out since the role was filled in 2008 and this will continue as the FSR oversees that standards are in place for all forensic science disciplines (from crime scene to court) and that all providers, operating within the CJS, are compliant. In achieving these challenging ambitions and ensuring there is a level playing field for the provision of services, the FSR role needs reforming and expanding to include responsibility for regulating the market and needs to be given a number of statutory powers to enforce and monitor compliance with the standards.

Acknowledgment

The authors would like to thank Dr. Gillian Tully, the current Forensic Science Regulator, for the opportunity to meet with her and for clarifying some of the issues covered in this commentary. Her opinions and comments helped greatly.

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Mandatory Breath Alcohol Screening in Canada — No More "Reasonable Suspicion"

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http://www.wigmoreonalcohol.com

The police in Canada now have a new and effective law enforcement tool with the enactment of Bill C-46 on December 18, 2018, called Mandatory Alcohol Screening (MAS) [3]. MAS has been used successfully for many years in other countries such as Australia, New Zealand,

and most European countries to reduce alcohol-related driving collisions. In Ireland there was a 23% reduction in overall traffic fatalities in the first year after MAS was introduced in 2006 [2].

Reasonable Suspicion?

Before Bill C-46, the Canadian police had to form "reasonable suspicion" before demanding a breath alcohol test via the approved roadside screening device (typically a portable, handheld fuel-cell device). Reasonable suspicion usually meant that the police officer had to detect at least the odor of an alcoholic beverage emanating from the breath of the driver, and probably some other indication of recent alcohol consumption such as admission of drinking or opened alcoholic beverage containers.

The odor of an alcoholic beverage is difficult to determine at the best of times, without being in a cold, windy external environment at the roadside that exists for many months in Canada. In one study [1], the ability of 20 experienced police officers to detect the odor of an alcoholic beverage from 14 drinking subjects was shown to be relatively poor even under ideal indoor conditions (*see* **Table 1)**.

In addition to the difficulty in detecting the odor of an alcoholic beverage, the police had to state in detail, later in court, how they arrived at the determination of "reasonable suspicion". If the court had any doubt as to the formation of reasonable suspicion, all the charges relating to alcohol-related driving would be dropped. This led to many prolonged drinking-and-driving trials in which the approved roadside screening device was used.

Mandatory Alcohol Screening in Canada

MAS now allows the police officer to demand a breath alcohol screening test at roadside from stopped drivers without any reasonable suspicion. In order to conduct a MAS,

- The car must be lawfully stopped;
- The driver must be in care and control of the vehicle; and
- The police must have the approved screening device close at hand.

It does not allow the police to demand breath samples from people in their homes or bars.

If the driver obtains a WARN reading on the screening device (0.050 to 0.099 g/100mL), a temporary suspension of up to 7 days will be issued, but there will be no criminal charge. If a FAIL results (0.100 g/100mL +), then the driver will be arrested and taken to the evidentiary breath alcohol instrument, where it will be the result of the lowest of two sequential breath tests that will be used for the criminal charge.

Table 1. Likelihood of detecting an alcoholic beverage odor coming from drinking subjects [3]

	Percent detected at BACs (g/100 mL)	
Type of beverage	0.04–0.08	>0.08
Beer	67	85
Wine	44	83
Vodka	60	59
Bourbon	80	72

Legal/Media Reaction

MAS is seen by the criminal defense bar as an unwarranted erosion of individual rights and against Canada's Charter of Rights and Freedoms. Some of the media headlines have emphasized this concern.

- **"The Liberals' police-state impaired driving law has to go"** (National Post, June 7, 2019)
- **"Sad day for charter rights: Police take heat for new mandatory breath sample law"** (CBC Manitoba, December 18, 2018)
- **"Are police violating your rights by testing for sobriety without cause?"** (Globe and Mail, February 5, 2019)
- **"Man with severe asthma says new police powers unfair for people unable to do breath tests"** (CBC, British Columbia, May 26, 2019)

Ultimately, the Supreme Court of Canada must determine that even if MAS is a violation of the Charter, that such a violation is justifiable in a free and democratic society and that any potential violation of rights is minimal relative to the benefits achieved, in order for the new law not to be declared unconstitutional.

Conclusion

By implementing MAS, Canada has joined the 121 out of 180 countries that the World Health Organization lists as having some type of mandatory alcohol-screening program for drivers. MAS should make detection of drinking drivers more effective and assist police in enforcing the criminal laws against drinking and driving, thus saving lives.

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Upcoming Events

American Academy of Forensic Sciences — 72nd Annual Meeting

Feb. 17–22, 2020; Anaheim Convention Center
Anaheim, CA, US

PITTCON Conference and Expo

March 1–5, 2020; McCormack Ppace — West Hall
Chicago, IL, US

Techno Security & Digital Forensic Conference

March 9–11, 2020; Hilton La Jolla Torrey Pines
San Diego, CA, US

Digital Forensics Research Workshop EU 2020

March 25–27, 2020; University of Oxford
Oxford, UK

American Society of Crime Laboratory Directors — Annual Symposium

March 29–April 2, 2020; Hyatt Regency Denver
Denver, CO, US

3rd Emirates International Forensic Conference and Exhibition

April 9–11, 2020; Dubai International Conference & Exhibition Centre
Dubai, UAE

California Association of Criminalists Seminar — Spring 2020

April 26–May 2, 2020; Hilton Santa Cruz
Santa Cruz, CA, US

Canadian Society of Forensic Science 2020 Conference

May 11–15, 2020; Ontario Tech University
Ontario, ON, Canada

Mid-Atlantic Association of Forensic Scientists — Annual Meeting

May 12–15, 2020; The Marriott at City Center
Newport News, VA, US

ICFSC 2020: International Conference on Forensic Sciences and Criminology

May 18–19, 2020; Venue to be announced
Montreal, QC, Canada

8th Edition of Forensics Expo Europe

May 19–21, 2020; ExCel
London, UK

The 3rd International Annual Congress on Controversies on Vannabis-Based Medicines

May 21–22, 2020; Radisson Blu Scandinavia Hotel
Copenhagen, Denmark

The Association of Firearm and Tool Mark Examiners — 51st Annual Training Seminar

May 24–29, 2020; Venue to be announced
Austin, TX, US

44th International Symposium on Capillary Chromatography and 17th GC×GC Symposium

May 24–29, 2020; Congress Centre
Riva del Garda, Italy

Chemistry World Conference

June 15–17, 2020; Holiday Inn Rome Aurelia
Rome, Italy

Digital Forensics Research Workshop USA 2020

July 19–22, 2020; Guest House at Graceland
Memphis, TN, US

International Association of Chiefs of Police — Training Conference on Drugs, Alcohol, and Impaired Driving

Aug. 6–8, 2020; Venue to be announced
San Antonio, TX, US

International Association for Identification — 2020 International Educational Conference

Aug. 9–15, 2020; The Rosen Shingle Creek
Orlando, FL, US

IFDAT 2020: The 10th Annual International Forum for Drug & Alcohol Testing Conference

Sept. 6–8, 2020; Imlauer Hotel Pitter
Salzburg, Austria

ISHI 2020: 31st International Symposium on Human Identification

Sept. 14–17, 2020; J. W. Marriott Hill Country
San Antonio, TX, US

Southern Association of Forensic Scientists; Midwest Association of Forensic Scientists; Southwestern Association of Forensic Scientists — Joint Meeting

Sept. 14–18, 2020; Sheraton Atlanta Hotel
Atlanta, GA, US

Society of Forensic Toxicologists — Annual Meeting

Sept. 21–25, 2020; Marriott Marquis San Diego Marina
San Diego, CA, US

25th Symposium of the Australian and New Zealand Forensic Science Society; 22nd Triennial Meeting of the International Association of Forensic Sciences — Joint Meeting

Sept. 22–25, 2020; International Convention Centre
Sydney, Australia

Northwest Association of Forensic Scientists — Annual Conference

Sept. 22–25, 2020; SLC Red Lion Hotel
Salt Lake City, UT, US

2020 International Conference on Forensic Nursing Science and Practice

Sept. 23–26, 2020; Westin Mission Hills
Palm Springs, CA, US

SCIX 2020 — Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies

Oct. 11–16, 2020; Nugget Casino Resort
Reno-Sparks, NV, US

Northeastern Association of Forensic Scientists — Annual Conference

Oct. 14–17, 2020; Marriott Mystic
Mystic, CT, US

International Association of Chiefs of Police — 127th Annual Training Conference and Exposition

Oct. 17–20, 2020; Venue to be announced
New Orleans, LA, US

International Conference on Forensic Science and Courts 2020

Oct. 22–23, 2020; Venue to be announced
London, UK

California Association of Criminalists Seminar — Fall 2020

Oct. 25–31, 2020; Los Angeles County Sheriff's Dept.
Los Angeles, CA, US

TIAFT 2020: 58th Annual Meeting of the International Association of Forensic Toxicologists

Oct. 31–Nov. 5, 2020; Cape Town International Conference Centre
Cape Town, South Africa

American Academy of Forensic Sciences — 73rd Annual Meeting

Feb. 15–20, 2021; George R. Brown Convention Center
Houston, TX, US

TIAFT 2021: 59th Annual Meeting of the International Association of Forensic Toxicologists

Aug. 29–Sept. 2, 2021; The Santo Spirito in Sassia Monumental Complex
Rome, Italy

ADVANCING THE PRACTICE OF FORENSIC SCIENCE IN THE US — UPDATE

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

Tuesday, November 12, 2019
AAAS Headquarters
Washington, District of Columbia
United States of America

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

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 pathbreaking NASEM report, "*Strengthening Forensic Science in the United States: A Path Forward*".

The welcoming comments were delivered by **Jessica Wyndham**, director of scientific responsibility, Human Rights and Law Program, AAAS. The morning's keynote address was moderated by **Deborah Runkle**, senior program associate for scientific responsibility, Human Rights and Law Program, AAAS.

Information related to the morning keynote address and the sessions that followed are listed in **Table 1**.

The afternoon's keynote address was moderated by **Anne-Marie Mazza**, senior director of the Committee on Science, Technology, and Law, NASEM.

Information related to the afternoon keynote address and the sessions that followed are listed in **Table 2**.

Overall, the conference provided numerous discussions, updates, perspectives, and presentations that focused on many of the developments, accomplishments, and challenges of the past decade in the forensic sciences and in the courts, as well as in federal agencies and laboratories.

Table 1. Morning session of the 10-year commemoration conference

Keynote Address
The Importance of Forensic Science and Its Place in the Scientific Enterprise

Thomas Albright
Professor and Conrad T. Prebys Chair
Salk Institute for Biological Studies
La Jolla, CA

Topic/Moderator	Speaker
Historical Perspectives: What Has Happened Since 2009	**John Butler**, Special Assistant to the director for Forensic Science NIST
Joanne Carney, Director Office of Government Relations AAAS	
Federal Agencies: Research and Funding	**Roecca Ferrell**, Program Director Division of Behavioral and Cognitive Sciences National Science Foundation
Alicia Carriquiry, Director Center for Statistics and Applications in Forensic Evidence Iowa State University	**Gene Peters**, Chief, Counterterrorism & Forensic Science Research FBI Laboratory
	Jonathan McGrath, Policy Analyst NIJ
	Robert Ramotowski, Forensic Science Program Manager NIST
Breakthroughs in Foundational Research	**JoAnn Buscaglia** (Latent Fingerprints), Research Chemist Counterterrorism and Forensic Science Research FBI Laboratory
Theresa Harris, Project Director Scientific Responsibility, Human Rights and Law Program AAAS	**Robert Thompson** (Toolmarks and Firearms), Senior Forensic Research Manager, Special Programs Office NIST

Table 2. Afternoon session of the 10-year commemoration conference

Keynote Address
An Australian Viewpoint

Linzi Wilson-Wilde, Director
National Institute of Forensic Science
Australia

Topic/Moderator	Speaker
Breakthroughs in Laboratory Management	**Linda Jackson**, Director Virginia Department of Forensic Science
Sarah Chu, Senior Science Policy Advisor Innocence Project	**Peter Stout**, CEO and President Houston Forensic Science Center
Human Factors/Cognitive Bias	**John Hollway**, Associate Dean and Executive Director of the Quattrone Center University of Pennsylvania Law School
Steve Pierson, Director of Science Policy American Statistical Association	**Melissa Taylor**, Senior Forensic Science Research Manager Forensic Science Research Program NIST
What's Happening in the Courts?	**Mark Larson**, Chief Deputy Criminal Division, King County Prosecutor's Office, Washington
Joe Cecil, Fellow School of Law University of California, Berkeley	**Julia Leighton**, General Counsel Public Defender Service for the District of Columbia (retired)
	Honorable Bridget McCormack, Chief Justice Michigan Supreme Court
Wrap Up: Looking Back and Moving Forward	**Richard Cavanagh**, Director Special Programs Office NIST
Glinda Cooper, Director of Science and Research Innocence Project	**Peter Neufeld**, Co-founder Innocence Project
	Jessica Wyndham, Director Scientific Responsibility, Human Rights and Law Program AAAS

NEW BOOKS AND BOOK REVIEW

New Forensic Science Books

A Hands-On Introduction to Forensic Science: Cracking the Case, 2nd ed

M. M. Okuda, F. H. Stephenson
CRC Press: Boca Raton, FL, US; 2019

Battlefield Forensics for Persian Gulf States: Regional and U.S. Military Weapons, Ammunition, and Headstamp Markings

D. Mikko, W. Bailey
CRC Press: Boca Raton, FL, US; 2019

Behavioral Forensics: Using Applied Behavior Analysis in Psychological Court Evaluations

D. Ruben
Academic Press/Elsevier: Waltham, MA, US; 2019

Child Abuse and Neglect: Forensic Issues in Evidence, Impact and Management

I. Bryce, Y. Robinson, W. Petherick, Eds
Academic Press/Elsevier: Waltham, MA, US; 2019

Crime Lab Report: An Anthology on Forensic Science in the Era of Criminal Justice Reform

J. Collins
Academic Press/Elsevier: Waltham, MA, US; 2019

Crime Scene Processing and Investigation Workbook, 2nd ed

C. R. Ramirez, C. L. Parish-Fisher
CRC Press: Boca Raton, FL, US; 2019

3D Data Acquisition for Bioarchaeology, Forensic Anthropology, and Archaeology

N. Seguchi, B. Dudzik, Eds
Academic Press/Elsevier: Waltham, MA, US; 2019

Effective Expert Witnessing, Fourth Edition: Practices for the 21st Century, 4th ed

J. V. Matson, S. F. Daou, J. G. Soper
CRC Press: Boca Raton, FL, US; 2019

Elder Abuse: Forensic, Legal and Medical Aspects

A. Carney, Ed
Academic Press/Elsevier: Waltham, MA, US; 2019

Expert Bytes: Computer Expertise in Forensic Documents — Players, Needs, Resources and Pitfalls

V. Atanasiu
CRC Press: Boca Raton, FL, US; 2019

Forensic Anthropology, 2nd ed

A. Christensen, N. Passalacqua, E. Bartelink
Academic Press/Elsevier: Waltham, MA, US; 2019

Forensic Examination of Signatures

L. Mohammed
Academic Press/Elsevier: Waltham, MA, US; 2019

Forensic Firearm Examination

C. Monturo
Academic Press/Elsevier: Waltham, MA, US; 2019

Forensic Psychiatry: Clinical, Legal and Ethical Issues, 2nd ed

J. Gunn, P. Taylor
Routledge/CRC Press: Boca Raton, FL, US; 2019

Implementing Digital Forensic Readiness: From Reactive to Proactive Process, 2nd ed

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

Introduction to Data Analysis with R for Forensic Scientists

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

Microbial Forensics

B. Budowle, S. Schutzer, S. Mors, Eds
Academic Press/Elsevier: Waltham, MA, US; 2019

Practicing Forensic Criminology

K. Fox Gotham, D. Kennedy
Academic Press/Elsevier: Waltham, MA, US; 2019

Why Don't We Defend Better? Data Breaches, Risk Management, and Public Policy

R. H. Sloan, R. Warner
CRC Press: Boca Raton, FL, US; 2019

Wireless Crime and Forensic Investigation

G. Kipper
CRC Press: Boca Raton, FL, US; 2019

Book Review

Introduction to Forensic Science and Criminalistics, 2nd ed

H. A. Harris, H. C. Lee
CRC Press: Boca Raton, FL, US; 2019

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This is the second edition of the book *Introduction to Forensic Science and Criminalistics*, which is designed to familiarize students with the basics of forensic science and criminalistics. As a valuable aid to teaching students, each chapter has a high-profile case at the beginning, which should interest any student who might enter the targeted fields. Other cases germane to the material in the chapter are presented in "Case Study" boxes wherever useful in a chapter. Likewise, wherever the science of a case needs further explanation, "Science" sidebars are inserted into the chapter. Once interest is piqued by the lead case, the learning objectives of each chapter are stated clearly in the "Objectives" box. In order to provide the reader with as much visual supplementation as possible, photographs and examples of actual results such as for bloodstains and thin-layer chromatography (TLC) are inserted throughout each chapter. At the end of each chapter, "Key Terms" are listed to reemphasize critical points in the material presented in the chapter. In order to challenge a reader's comprehension of the material in each chapter, "Review Questions" along with "Fill in/multiple choice questions" are also offered at the end of each chapter. Each chapter is well referenced.

Chapters 1 and 2 define the basics for forensics/criminalistics and look into admissibility of evidence, which is critical in the legal field. Basic definitions, which are used in subsequent chapters, are given to provide the reader with clear meanings for terms such as identification, corroboration, and documentation.

Chapter 3 brings out the important distinction between crime scene processing and analysis. Excellent practical information for types of scenes, the actual steps involved in scene processing, scene security, evidence recognition, documentation, collecting and preserving physical evidence, scene analysis, and reconstructions are laid out. As is found throughout the book, noteworthy crimes and their investigation are presented to emphasize the use of the techniques described.

Chapter 4 covers the examination and interpretation of patterns for reconstruction. As is true for all chapters, Chapter 4 starts out with a high-profile case. The case described involves blood spatter analysis. Blood spatter angle and angle of incidence may be somewhat confusing to a novice. However, the two calculations are clarified quite nicely in Sidebar 4.1. Patterns such as those seen with breaking glass and post-fire burn patterns are interesting to even the casual observer.

Chapter 5, "Examination of Physical Pattern Evidence", follows the same arrangement as other chapters. Chapter 5 does a good job of covering impressions and weapons, tool, and other object marks.

Chapter 6 covers the basics of fingerprints and other personal identifying marks. The history of fingerprints and the specifics of obtaining, preserving, and using them for identification are covered well in this introductory chapter. Biometrics including the term anthropometry are introduced in Chapter 6 along with their use for authentication and individualization, and limitations are presented at the end of the chapter.

Chapter 7 turns to the interesting field of questioned documents. Not only is handwriting covered, but also areas such as typewritten documents. Watermarking and other areas not normally seen by the public are discussed in detail in what is a very interesting chapter.

Chapter 8 addresses firearms and toolmarks. The firearms subsections cover commonly known areas such as rifling on fired bullets and other less known but extremely important areas including the new science of breech marking. In addition to the firearm itself, the subject of gunshot residue is covered in this chapter. Toolmarks are discussed from the viewpoint of: (a) the tool itself having marks on it from being used; and (b) the object the tool was used on carrying the marks of the tool and leaving any residue from the tool on the object the tool was used on.

Chapter 9 addresses the new and growing field of digital evidence. The chapter provides useful definitions and the basics of digital information storage, transfer, and retrieval. The appendix to the chapter gives the reader a quick selection of practical, useful electronic tools. Chapter 9 also has two cases in which digital evidence was valuable.

Chapter 10 looks into the broad area of blood and physiological fluid evidence. Serology is presented as a science that has in many ways been replaced by DNA (deoxyribonucleic acid). Practical methods for collection, preservation, and packaging of biological evidence including blood are presented. The forensic identification of blood and its elements is presented and discussed. Semen along with its determination and handling of sexual assault cases is discussed in great detail. A short presentation of so-called "date rape drugs" provides some insight on

another avenue of sexual assault. It should be pointed out by anyone using this book for teaching that, after saliva is produced, it mixes with other contents of the oral cavity to become what is now correctly referenced as oral fluid. This is important as oral fluid currently is a common forensic toxicologic specimen for analysis and will become more common in the coming years.

Chapter 11 discusses DNA and typing. A brief introduction to inheritance and DNA is provided at the beginning of the chapter. Both nuclear and mitochondrial DNA are addressed in this chapter. Practical information for the collection, isolation, and typing of DNA is provided. The power to individualize using DNA is presented in a strong case for its use in the chapter. DNA also is presented as an exclusionary tool. CODIS (Combined DNA Indexing System) and the use of both 13 (CODIS) and 20 (Expanded CODIS) STRs or Short Tandem Repeats plus amelogenin for gender determination is presented.

Another interesting but sometimes considered obscure area of forensics, arson and explosives, is discussed in great detail in Chapter 12. Combustion and fires and what to anticipate in a fire scene are addressed. Practical information designed to aid in the proper collection and submission of post-fire evidence is provided. Explosions and explosives are presented along with evidence that may remain post-explosion and how to collect and submit it plus its analysis are given in the latter part of the chapter.

Chapter 13 addresses drugs, drug analysis, and results interpretation, which is forensic toxicology. The major drug classes (e.g., analgesics, stimulants) are discussed briefly along with their effects on human beings. Separations of drugs that are found in admixture or in a complex matrix such as blood are addressed prior to dealing with drug and drug metabolite analysis. Figure 13.10 will require considerable input from a professor/teacher to expand the diagram to cover the metabolism of all drugs germane to forensic toxicology. Under "metabolism" on page 349, it was this reviewer's experience that the best time to observe an active parent drug and, where possible, correlate it with symptomatology was shortly after use, which was usually right after an arrest or accident. The section on breath analysis is somewhat outdated as most current breath analyzers employ either fuel cell or infrared technology.

Chapter 14 is on materials evidence. Collection methods, laboratory methods of analysis, and the most common types of evidence are described. There is a good section on hair. The only item missing from the hair discussion is a very brief subsection on drugs/drug metabolites in hair, which is currently a common analysis and will have greater use and significance in future years. Chapter 14 provides a great deal of practical information and advice with respect to the collection, handling, transportation, receipt/processing, analysis, and storage of material evidence.

Appendix A, "The Scientific Tools of the Trade," provides a short but good summary of what is available for the analyses mentioned in the preceding chapters. The only possible misconception in Appendix A is under SPECTROMETRIC AND SPECTROSCOPIC METHODS on Page 403 where it is stated, "The ions formed are specific to a given compound." It should by explained to students that common ions such as m/e 58 are due to the formation of $H_3CCH_2N^+CH_3$, which is formed from such widely varying drugs as methamphetamine, amitriptyline, and doxepin. Teachers/professors who are using this book as classroom material probably will want to supplement what is in Appendix A with instrumentation they have used in the past or what is currently available to them; especially what students may use in any laboratory portion of their course. Other areas where a student might not obtain a correct impression of a forensic procedure have been discussed above on a chapter-by-chapter basis and can easily be pointed out to students by faculty. Otherwise, the book is an easy read and highly informative.

I highly recommend this book to students who are beginning their career or considering a career in forensics and/or criminalistics as well as to their professors/teachers. I also recommend it to individuals who are interested in either or both fields, to forensic science practitioners who are currently practicing in a relatively narrow area and would like to obtain a broader view of the fields of forensics and criminalistics; as well as to clinical practitioners who have an interest in how their clinical data may be used forensically. If teaching a semester-long course on the introduction to forensics, this is a book I would seriously consider using.

TEITELBAUM'S COLUMN ON FORENSIC SCIENCE — HISTORICAL PERSPECTIVE —

Alphonse Bertillon — Whose Legacy as a Pioneer in Criminal Identification Was Undone by Fingerprinting — May Have Solved the World's First Fingerprint Murder Case

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A newspaper headline from 1902 (**Figure 2**) neatly sums up this story.


How the Celebrated Alphonse Bertillon, Chief of the Anthropometric Service of Paris, Discovered an Unknown Murderer by Means of a Greasy Thumb-Print Left on the Glass Door of a Coin Cabinet Thereby Achieving the Greatest Triumph Ever Recorded for This Method of Criminal Detection

Figure 2. *The Philadelphia Inquirer*; December 28, 1902 [Public domain].

Before fingerprinting became the standard for identifying criminals in the late 1800s, Alphonse Bertillon singlehandedly created an identification system that was based on a complex series of physical measurements and photographs. He called his system *Anthropometry,* and it was adopted and used by countries all over the world — from England, France, and Switzerland to Russia and in many parts of the US. Anthropometry was a towering achievement. For the first time, records of extremely detailed information about criminals could be maintained, organized, and accessed in order to identify the identity of a suspect. Bertillon was also a pioneer in the use of the camera for criminal identification purposes, and he is often credited as the inventor of the criminal mugshot. Although cameras had been utilized by police departments for several decades, Bertillon indisputably formalized the use of photography as a system of criminal identification and documentation in the late 1880s.

Bertillon officially established the Anthropometric Service within the Paris Prefecture in 1885, and his system would enjoy years of success. Toward the end of the century, however, the focus on fingerprinting as a tool for identifying criminals began to attract many law enforcement practitioners. Bertillon's anthropometric system, while theoretically sound, could be rendered virtually useless due to factors such as the variables of the measuring tools or the quality of the training of the person taking the measurements. One writer commented:

Figure 1. Alphonse Bertillon [Wikimedia Commons].

> *"I have seen so-called experts measuring prisoners without even knowledge of where to place the instruments, obtaining results so ludicrously inaccurate as to eliminate any chance of identification."* [1]

Bertillon strongly resisted the field of fingerprinting as an enemy to his beloved measuring system. Even though he respected his friend, Francis Galton, who had developed one of the earliest fingerprint classification systems, fingerprints had never solved a major crime. Still, Bertillon realized that fingerprints did have value and soon began incorporating them into his criminal file records, even developing new techniques for photographing fingerprints.

On October 17, 1902, in Paris, a dentist named M. Alaux reported to the police that he had returned to his apartment and found his servant, Joseph Reibel, choked to death on the floor. Some money was missing, drawers and closets had been opened and their contents tossed about, and the glass doors of a cabinet had been broken. There are conflicting details from newspapers and various published accounts of how Bertillon became involved in the case [5]. Several newspapers quoted Bertillon as saying that he saw photographs of the crime scene back at the police prefect, noticed some white marks on the broken cabinet glass, thought that they might be fingermarks, and immediately rushed to the crime scene to examine the evidence. He claimed that he cut out two pieces of the glass and gave each piece to policemen who were with him, instructing them to travel back to the Anthropometric Service offices separately so that if one of them had a mishap, the other piece of glass would arrive safely. Other accounts have Bertillon as one of the first to arrive on the crime scene, where he immediately noticed the fingerprints on the glass and had it taken back to his offices to be photographed. But most accounts provided details of the care and professionalism he demonstrated in photographing the glass. One of his primary challenges lay in the fact that the suspect had gripped both sides of the glass, pressing his thumb against one side and several

fingers against the other side, so Bertillon had to conduct many experiments in order to produce separate images that clearly showed the prints (**Figure 3)**. He worked with a variety of backgrounds, lights, and camera angles and ultimately settled on bright arc lights against a dark background.

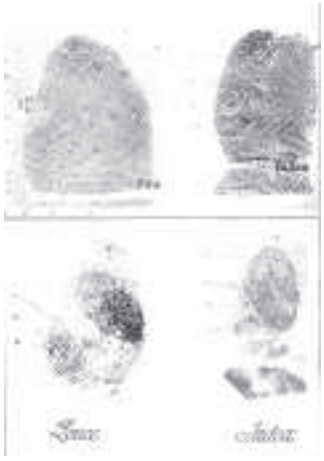

Figure 3. Scheffer's fingerprints: The upper pair are from the Anthropometric Service of Paris; the lower pair are from the broken glass [2].

Although more than 300,000 criminals had been measured and logged into the Anthropometric Service files, Bertillon only had 90,000 records for which criminals had been fingerprinted. Although 90,000 files were still a daunting number to search, his chances of success were reduced by not being able to search the entirety of his files. Fortunately, he was able to produce a match within three hours.

Bertillon was able to dramatically tell Cochefert, the chief of the sûreté, to arrest a man named Henri Scheffer while providing a photograph of him (**Figure 4**), a copy of his fingerprints (Figure 3), and detailed information about his appearance. Scheffer had been arrested the previous year and all of his measurements and photographs were in Bertillon's files. Alaux, the apartment owner, immediately recognized Scheffer when presented with a photograph of him. Scheffer was eventually located and arrested and he soon confessed to the crime.

There are also conflicting reports regarding Scheffer's relationship with Joseph Reibel. Some accounts describe a romantic relationship between the men and that a break-up led to Reibel's death. Other accounts have Scheffer planning to rob Alaux's apartment with Reibel but that a dispute as to how they should divide the money led to a fatal altercation.

News accounts heralding Bertillon's fingerprint case appeared in newspapers around the world. Not long

Figure 4. Henri Leon Scheffer [Wikimedia Commons].

after the conclusion of this case, however, the Bertillon anthropometric system would begin its rapid fall into disfavor. It was the following year, in fact, in 1903, that the now-infamous misidentification regarding Will and William West in the US's Leavenworth Penitentiary [6] would mark the precise start of the Bertillon decline. Perhaps, as mentioned earlier, the error lay in the inexpertise of the people taking the measurements, and that, if accurately done, the system would have worked. Bertillon would undoubtedly have preferred a legacy in which his anthropometric system was considered to be the super identification system, but, unless historical information of an earlier fingerprint case should come to light, Bertillon was the first criminal investigator to solve a murder case solely on the evidence of a fingerprint.

> *"On this evidence it is not possible to deprive Bertillon of the merit of being the first expert in Europe to effect the solution of a murder investigation upon fingerprint evidence alone."* [3]

> *"... in the Scheffer case, the murderer was quite unknown and unsuspected; it was solely by comparing the traces found on the broken glass of the cabinet with the fingerprints of individuals filed in his anthropometrical collection that Bertillon succeeded indicating to the police — who were at that time quite unaware of the fact — that the murderer was Scheffer. The case excited universal interest; this date: October 24th 1902, marks indeed the introduction of fingerprints as sole proof in criminal enquiry*." [4]

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COMMENTARY

Forensic Science in the UK — At a Crossroads or at the Edge of a Precipice?

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John Cassella received a degree in medical laboratory sciences and chemistry from the University of Leicester in 1988 and a doctorate in orthopedic pathology from the University College of London (Royal National Orthopaedic Hospital: Stanmore, UK). He has published widely in medical and related biomedical sciences and in forensics. Working in many of London's major teaching hospitals in medical research and teaching medical students as a lecturer in biomedical sciences and subsequently a reader (associate professor) in biomedical sciences and "programme leader" for the forensic science degree at the University of Derby. He joined Staffordshire University in 2005, teaching elements of forensic pathology as well as techniques of human identification and body recovery from disaster situations. Conferred a Professorial Chair in Forensic Science Education in 2008 with over 70 journal publications and books, Dr. Cassella sits on a number of groups that work at a national level to promote the development and improvement of the delivery of forensic education and improve the links between academia, the forensic industry, and UK police services. He sits on a former Home Office Group (now part of DSTL) for search techniques development and is a workstream lead for "rapid services and custody suites" for the Staffordshire Police-Staffordshire University partnership. John is an associate with Kenyons International Emergency Services and was deployed to Grenfell Tower in 2017.

United Kingdom House of Lords Report

> *"A free society is dependent on the rule of law which in turn relies on equality of access to justice. Simultaneous budget cuts and reorganisation, together with exponential growth in the need for new services such as digital evidence has put forensic science providers under extreme pressure. The result is a forensic science market which, unless properly regulated, will soon suffer the shocks of major forensic science providers going out of business and putting justice in jeopardy."* (Lord Patel, Chairman of the Committee, 2019 House of Lords, United Kingdom)

On May 1, 2019, a 66-page report was produced for public dissemination by the Science and Technology Select Committee in the United Kingdom House of Lords, the highest of seats in UK government [9]. This report had many hundreds of pages of written testimony appended to it as well as transcribed oral testimony (and videoed evidence on-line) given to the inquiry: *https://www.parliament.uk/forensic-science-lords-inquiry*. It represented hundreds of hours of work by numerous institutions, companies, groups, and individuals. The committee's report cited those persons (forensic scientists, representatives of forensic science providers, legal representatives, etc.) who presented oral evidence and written evidence testimony, correspondence with government ministers, and a variety of associated evidence. The report was titled "*Forensic Science and the Criminal Justice System: A Blueprint for Change*". From its very title therefore, implicit in the paradigm of this report was indeed a *need for change* and a possible blueprint for that change.

Among its many points, the report noted acutely that:

> *The UK was once regarded as world-leading in forensic science but an absence of high-level leadership, a lack of funding, and an insufficient level of research and development now means the UK is lagging behind others. The forensic science market is not properly regulated, creating a state of crisis and a threat to the criminal justice system.*

Despite the desire to be world-leading and to develop research to keep at the forefront of technology, a key concern must be the comments concerning a lack of regulation and indeed a clear threat to the facilitation of the criminal justice system (CJS).

There exists at this time then the opportunity to improve many aspects and facets of UK forensic science or to run the risk that something detrimental could occur. What is meant by that? Simply put, that the possibility exists that a process or procedure is not conducted to the optimal standard or that a test is not done or is poorly interpreted or reported, which results in an innocent person being convicted or a guilty person being found not guilty in the UK courts. This must not be considered as scaremongering, for it is not intended to be but it is the worst-case scenario that the hard-working scene-of-crime officers and forensic scientists in the UK always have in the back of their minds so they can be confident they have considered all aspects of their evidence collection and preservation of continuity and the subsequent testing and reporting in whichever discipline they work.

The Forensic Science Regulator

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

- Make sure the correct standards are delivered appropriately to meet the needs of the CJS;
- Advise and guide the forensic science providers, ministers, and others; and
- Ensure effective means to investigate quality failures, and to collaborate nationally and internationally to keep UK-wide quality standards [4–6].

The FSR is supported by a team of government civil servants with additional support provided by the Home Office, as well as a Forensic Science Advisory Council (FSAC). Also key, the quality standards used in forensic science are those lying under the norm ISO/IEC 17025 and those forensic providers willing to develop work for the police or the forensic services need to be accredited by the UK Accreditation Service (UKAS) [10]. The UKAS accreditation provides assurance of the technical competence of a laboratory to undertake specific analysis.

It also reviews different areas relevant to the CJS such as continuity of evidence, management of case files, and storage of exhibits. The UKAS ensures that the staff developing the essays are competent and qualified to do so, methods are robust and suitable, equipment is appropriate and kept and maintained adequately, and internal and external quality controls are implemented. All private forensic science providers contracted to provide services must also be accredited. However, this same principle does not apply to police forensic laboratories, a situation that has proved to be controversial.

The lack of regulation would be thought to be directed at the UK FSR, who would be expected to naturally rebut such an overt statement, since such a remit falls upon the FSR role. However, the FSR issued a stark warning that:

> "*profound changes to funding and governance are required to ensure that forensic science survives and begins to flourish rather than lurching from crisis to crisis.*"

The FSR emphasized that the focus of the government should be on "the protection of justice rather than the protection of historic or current policies" [9].

There are therefore strong words from key UK stakeholders and thus one would consider deserving of immediate action, yet as this commentary will consider, the profound and concerning response appears to be a silence of any obvious public dialogue whatsoever, or of any plans or indeed roadmaps to address the serious issues raised by the report.

Forensic Science in the US, Scotland, and the UK

There appears, to the voting public and to those in the forensic industry, to be no discussion of immediate injections of public monies to strengthen the day-to-day conduct of forensic science laboratory investigations in the UK or for that matter the parallel situation that has occurred in the US. There is no drive to recruit further scientific staff or to invest in further forensic facilities or infrastructure or indeed to improve the existing management and accountability of forensic science. In some ways this is no surprise; following the publication of a lengthy report by the President's Council of Advisors on Science and Technology (PCAST) in September 2016 [14] in which it recommended actions to strengthen forensic science and promote its more rigorous use in the courtroom, little appears to have changed in the US. The study that led to the PCAST report was a response to then President Obama's question to his PCAST in 2015, as to whether there are additional steps on the scientific side, beyond those already taken by the Administration in the aftermath of a highly critical 2009 National Research Council report on the state of the forensic sciences [13], that could help ensure the validity of forensic evidence used in the (US) nation's legal system. The public-facing effect of such ongoing issues is a perceived reduced confidence in the science used in the courtroom.

Balko, an opinion writer in the *Washington Post*, said in June 2019 that:

> "*… the courts have done a poor job of keeping junk science and dubious expertise out of criminal trials. The pattern-matching fields of forensics — in which an analyst compares a piece of evidence from a crime scene to a piece of evidence thought to implicate a suspect — are largely subjective, lack structure and standards, and are hobbled by cognitive bias. And the legal system is too reluctant to revisit, and correct old cases affected by these problems.*"

During the previous decade there have been nine major reports on forensic science [1,7,8], each of them published with numerous assessments of the current state of forensic science within England and Wales and with recommendations to address the challenges. Concurrently over this time period, there have been two influential reports from the US addressing similar issues within forensic science in that nation.

Some of the concerns raised in these reports include:

- Major crimes potentially could go unsolved unless the government did more to support forensic science.
- Forensic science provision was under threat because the police were increasingly relying on unregulated experts to examine samples from suspects and crime scenes, and cost has become a greater factor in the tendering process than quality.
- Without statutory powers to enforce compliance, the (UK) FSR could not ensure that science being used in the CJS is being carried out to the required standard.
- Challenges in relation to the use of digital forensics included the availability of skills, the global nature of cybercrime, the scale of digital forensic investigations, the interface between digital information and physical information, ensuring information was shared in accordance with the requirements of disclosure, and communicating this highly technical information throughout the criminal justice process.
- The scientific evidence base for different types of forensic science was variable and, in some cases, very limited.

The new line of communication, launched by the FSR in association with the (UK) charity *Crimestoppers*, allows forensic science professionals to raise concerns about service quality to the FSR without revealing their identity. Quality failures, such as sample contamination or data manipulation, could allow innocent people to be wrongly convicted or offenders to escape justice. This confidential communication path has been designed to ensure that any serious issues are flagged to the FSR even if an individual felt unable to report through the whistleblowing procedures in their own organizations. And yet surely this is the admission of failure in itself. If one cannot, for something of such importance to us all, be open and protected in the law for raising concerns, then surely, the battle is already lost. Surely at some point any concerns about quality or work practices may themselves end in a court case in which those anonymous individuals would have to give their factual evidence in court.

A longstanding issue in the UK is the current structure having 43 different police authorities across the UK who suffer with issues of "interdepartmental cooperation and coordination" — some authorities conduct their forensics operations in-house, while others have outsourced forensic investigation to private firms since the closure of the national Forensic Science Service in 2012, with no consistency across authorities.

The Scottish Police Authority is responsible for providing a Forensic Services unit to support operational policing in Scotland. One of the central tenets of the Police and Fire Reform (Scotland) Act is that Forensic Services are not under the direction and control of the chief constable. Instead these services are managed and delivered as part of the Scottish Police Authority, ensuring a suitable degree of independence and impartiality while also supporting the unique crime-scene–to–court partnership that Forensic Services has with both operational policing and the wider CJS in Scotland.

The model of a single Scottish forensic service appears to offer a possible solution to this fragmentation into 43 services and yet there appears to be little discussion about developing this as a model for the whole of the UK. It was the UK Forensic Science Service who conducted a lot of the forensic science research before its closure in 2012. The questions asked were predominantly designed to help answer operational questions that arose in conducting their role in supplying forensic science to the CJS.

Higher Education Institution, Technology Industry, and Forensic Science

Now let us briefly consider the role of higher education institutions (HEI) — universities, in the current landscape of forensic science in both the UK and the US. The core role of any HEI, as fundamentally driven by financial models, is to conduct teaching; this is followed by research. Even those considered to be Russell Group institutions (a collection of 24 universities in the UK that are renowned for the quality of their research) are having to bow to a financial realignment of changes in government funding for HEIs and look to larger student intakes and the income generated from their fees. There is also no remit or expectation for conducting *forensic* research in any UK HEI at this time and there is unlikely to be any formal strategy for such an endeavor in the future. The research is therefore conducted and driven by the research interests (or the ongoing individual HEI strategy based on the in-house skills and experience of its staff). This may seem an ad hoc plan for forensic science research, but it is the organic growth mechanism for many research specialisms in UK universities. This has had strengths and indeed weaknesses. With no national strategy for forensic-driven research, it has resulted in some disciplines within forensic science lacking in the quantity and indeed the quality of forensic science research such as those disciplines mentioned in the PCAST report of 2015 [14]. Those forensic disciplines that attract UK Research Council funding are those that prosper in the amount of research done; those that do not, simply don't prosper.

So at this point the picture appears bleak and somewhat challenging in terms of the conduct of forensic science practice based on evidence collected from crime scenes. Even more challenging for academics in forensic science research in the UK is the reduction in public (grant) funding available for science in general through the Research Councils (RCUK) [9].

However, let us consider a SWOT (strengths, weaknesses, opportunities, and threats) analysis in which we have clearly above addressed some of the weaknesses and threats in forensic science. The value of a SWOT analysis is to help reduce or eliminate the weaknesses and the threats and to uncover opportunities that any industry is well placed to exploit.

Let us consider a few of these as examples:

- Changes in government policy related to the field;
- What interesting trends we are aware of;
- Changes in technology and markets on both a broad and narrow scale;
- Changes in social patterns, population profiles, lifestyle changes, and so on; and
- The innovation and technology.

In terms of changes in government policy related to the forensic science field, the "blueprint for change" report by the UK House of Lords [9] makes a clear statement as to what needs to be improved — this the is the road map for operational and infrastructural changes imminently needed.

If forensic science is to contribute effectively to the CJS, the science must be considered trustworthy. Two key components of this are quality standards and training. The use of UK UKAS ISO 17020 and 17025 used in forensic laboratories will begin to address this and yet there is clearly work to be done in that these systems are lengthy processes to inculcate into everyday practice, abstracting key staff in the creation of protocols for the accreditation and comments in the House of Lords inquiry with observations such as:

> "*UKAS lack experienced, active forensic practitioners to be used as Technical Assessors within some forensic disciplines*"

and

> "*… the assessors often do not interpret the standard in the same way and accept methods in one force which are challenged in another*."

Within the forensic industry over the past few years there has been a wider understanding and an acceptance to tackle the issue of bias [11] and also to better inform those key stakeholders in the true value of the forensic evidence being presented [15,16]. There is now a much stronger appreciation of the issues of cognitive bias in the industry and there has been a significant improvement in industry intention to reduce or indeed eliminate it. Researchers from the University of Leicester stated that it:

> "*… requires more research focused on human factors in forensic science, including better understanding of the cognitive process of pattern recognition, the psychological nature of 'expertise', and sources, causes, and consequences of cognitive bias*."

And, interestingly, a statement given in oral evidence observed that:

> "*… human biases might be replicated by some of these machine-learning systems"* and that *"with artificial intelligence, it is very hard to explain what happened and how the machine came up with a particular answer*."

But the appreciation that humans can affect how machine are designed can at least begin to reduce such issues at the research and development stage of future forensic technology. There is much to discuss in terms of the development of the understanding of bias in forensic science and the need also to continue the ethics framework for what is appropriate and acceptable to society, but that is outside of the scope of this commentary. Equally the rising concerns of the use of biometrics and also a lack of strategy to address the exponential rise in digital forensic evidence need to be considered further.

The changes in technology and markets are possibly the most profound and wide-reaching at any time since forensic science began as a discipline. Examples include the improvements in digital forensics technology for analyses, the use of biometrics, and key elements of that such as facial recognition algorithm developments. Microbiomic identification, although a cutting-edge technology, is not ready for use in the courtroom, but scientists predict its use in convicting perpetrators of sexual assault, for example, could soon be a possibility. Virtual autopsies are noninvasive, damaging neither the body nor forensic evidence. In this process, 3-D models are used, and computer acquisition of data allows an immediate second opinion, should it be needed. The procedure is not widely used at present because it is fairly expensive, but the cost will decrease as virtual autopsies are conducted more frequently in the future.

"Transforming Forensics" is a program created to design and build forensic services that will offer better protection to the communities being served and the best possible service to victims of crime [12]. Forensics in policing provides a vital service and can and should demonstrate creativity and flexibility. Often innovations developed in one police force are not exploited across other forces. At present, forensic science services in the UK lack the scale, speed, and capability needed fully to support investigations with cutting-edge tools, processes, and science. The areas currently in their work program are: fingerprints, ISO accreditation, and digital forensics.

Introduced more than seven years ago, streamlined forensic reporting (SFR) was designed to bring in a nationally consistent reporting system and to generate both time and cost efficiencies; the response to its introduction

has varied [2]. It appears to be fundamentally a revised case-management procedure for producing forensic evidence at court; it seeks to reduce costs, bureaucracy, and potential delays in the CJS, with obvious financial benefits for all stakeholders. It takes a more proportionate approach to forensic evidence through the early preparation of a short report detailing the key forensic evidence on which the prosecution intends to rely. The aim is to achieve early agreement with the defense on forensic issues but where this cannot be achieved in the first instance, to identify any contested issues.

Edmond et al. [3] commented that:

> "*In overlooking quality, SFR introduces new risks of misrepresentation, misunderstanding and mistakes, and is unlikely to align with long-standing and fundamental criminal justice values (such as transparency, rationality, rectitude, equality of arms and fairness), and so is unlikely to fulfil the fundamental goal of dealing with cases justly.*"

Therefore, although SFR is designed with good intentions, it has issues that require consideration.

Conclusion

It becomes quite clear from the brief commentary above, that there are significant challenges ahead for the UK industry that is under the umbrella of disciplines forming "forensic science" — encompassing practitioners, educationalists, stakeholders. It would be too simple to say that the industry is in a difficult place and doom-monger further, and yet the reality is that forensic science still functions within both the practitioners' and the educationalists' worlds; it is not collapsed and nonfunctional. Could it be better? *Absolutely* it could be: Using the philosophy and the power of a SWOT analysis, with a little thought, it could assist in identifying opportunities that forensic science is well-placed to exploit rather than languishing on the negative aspects in the current forensic arena. By understanding the weaknesses of the forensic "business", the UK forensic landscape being at a crossroads or indeed the *edge of a precipice* can now choose to manage and eliminate potential threats to its policy, practice, and reporting that would otherwise catch it unawares, or it may await the worst possible outcomes in miscarriages of justice.

The House of Lords (UK) 2019 [9] report's summary concluded:

> "*This report follows others that have raised similar concerns, yet the changes that are necessary have not been made, despite acknowledgments that they would be. Forensic science in England and Wales is in trouble. To ensure the delivery of justice, the time for action is now.*"

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