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M. R. Baylor (Editor)
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United States of America

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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.

The State of Forensic Science in Australia and New Zealand

Linzi Wilson-Wilde

National Institute of Forensic Science
Australia New Zealand Policing Advisory Agency
Melbourne, Victoria
Australia
linzi.wilson-wilde.nifs@anzpaa.org.au

The National Institute of Forensic Science

Established in 1992, the National Institute of Forensic Science (NIFS) is a unique body with a strategic intent to promote and facilitate excellence in forensic science in Australia and New Zealand [1,2]. NIFS was incorporated as a directorate within the Australia New Zealand Policing Advisory Agency (ANZPAA) in 2008 and is governed by the Australia New Zealand Forensic Executive Committee (ANZFEC), under the oversight of the ANZPAA Board [2].

ANZFEC consists of the directors/heads of the government forensic service providers, who represent these member agencies to ANZPAA NIFS under a Service Level Agreement. Australian and New Zealand Police Commis-sioners and the Australian Capital Territory Chief Police Officer together comprise the ANZPAA Board [2]. The governance structure of ANZPAA NIFS is represented in **Figure 1**.

ANZPAA NIFS has a unique overview of the Australia New Zealand and international landscapes applicable to forensic science. Its cross-jurisdictional position facilitates an ability to make connections and see the broader issues, to ultimately drive change. As a key point of contact and a facilitator, ANZPAA NIFS can take advantage of the multiagency resource collective and buying power to deliver results that a single agency could not achieve independently in a timely manner.

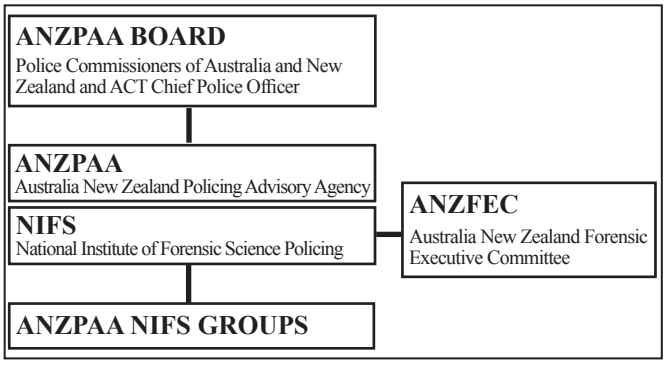

Figure 1. Governance structure of National Institute of Forensic Science within the Australia New Zealand Policing Advisory Agency.

ANZPAA NIFS work programs are designed to address priority needs and issues in forensic science. It can be viewed as a community cooperative: funded by the community, for the community. Its focus is on positioning the community for the future, reducing risk and creating efficiencies through the roles of coordinating cross-agency projects, promoting research, information exchange, cross-agency education and training, and promoting quality [2].

ANZPAA NIFS Groups

The ability for ANZPAA NIFS to achieve results and effect change relies on its relationship and facilitation of numerous forensic specialist groups. Membership to the groups is largely sought through ANZPAA NIFS member agencies. ANZPAA NIFS facilitates two permanent standing groups: the ANZPAA Disaster Victim Identification Committee (ADVIC) and the Chemical Warfare Agency Laboratory Network (CWALN), and 12 permanent nonstanding specialist advisory groups (SAGs), i.e., Biology, Chemical Criminalistics, Crime Scene, Document, Drug, Electronic Evidence, Face, Fingerprint, Firearm, Medical Sciences, Quality, and Toxicology [3].

The SAGs are in turn supported by Technical Advisory Groups (permanent virtual groups) and Project Working Groups (temporary virtual groups), the latter of which can also be created to directly support ANZPAA NIFS projects. These groups are integral elements to ANZPAA NIFS achieving its aims (*see* **Figure 2**).

In addition to the groups above, ANZPAA NIFS manages further groups that assist in delivering its work program. The work of these groups will be discussed further in this paper and include:

- Research and Innovation Advisory Committee (RIAC);
- Australasian Forensic Science Assessment Body (AFSAB); and
- Crime Scene Proficiency Advisory Committee (CSPAC).

Government Service Providers in Australia and New Zealand

The government service providers in Australia and New Zealand are listed in **Table 1** by country and state/territory. The forensic service provision has a different structure in each jurisdiction. In some jurisdictions the service is provided solely by police, in others it is split between police and health, justice, or science, or a combination (see Table 1). Niche services (e.g., entomology and odontology) are provided by specialists in academia. There are also some limited private forensic service providers (e.g., document examination), as well

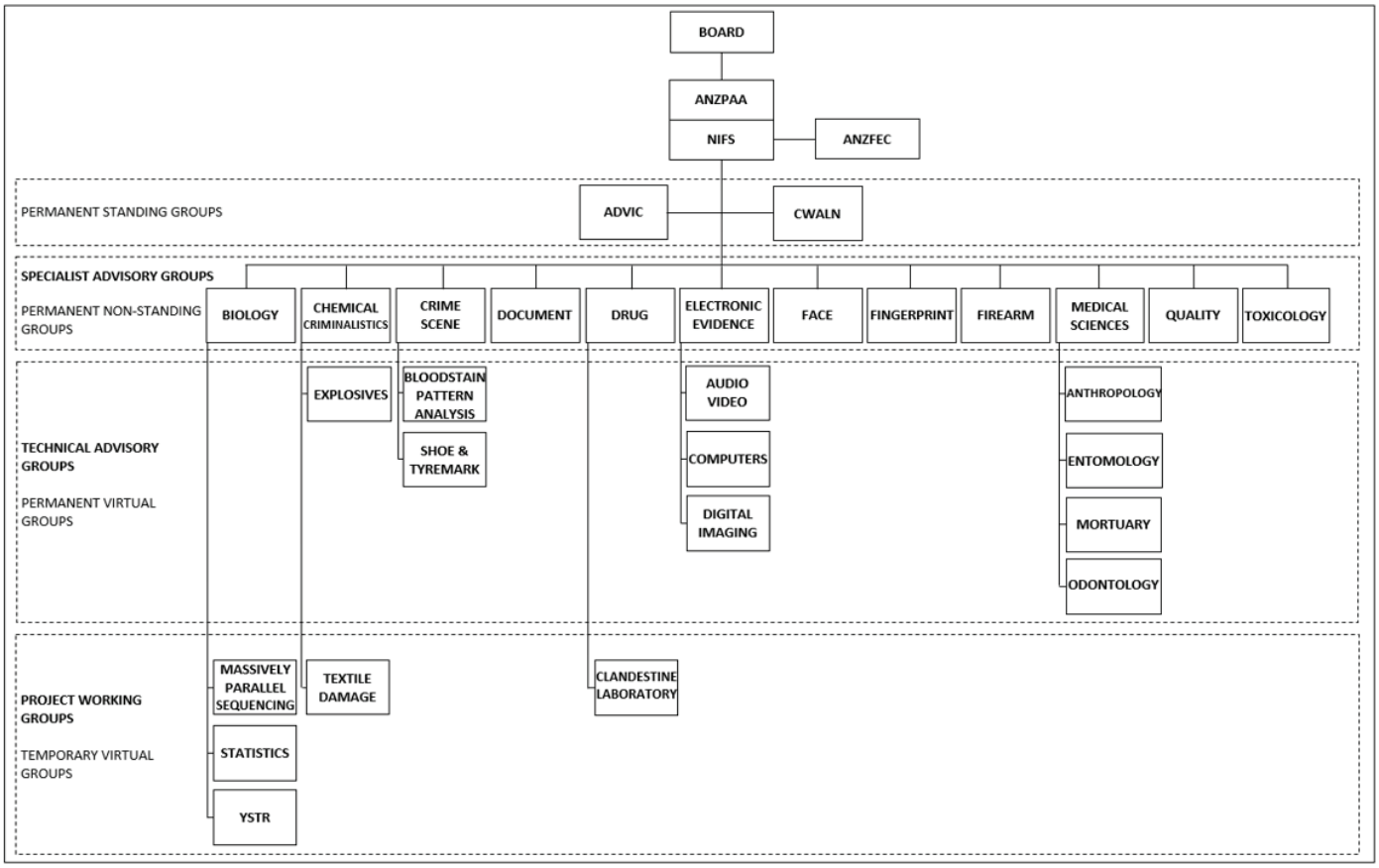

Figure 2. Structure of the ANZPAA NIFS groups.

Table 1. Government service providers in Australia and New Zealand

Country; State/Region	Agency	Sector
Australia		
Australian Capital Territory	• Australian Capital Territory Policing	Police
	• Australian Capital Territory Health Directorate	Health
Federal	• Australian Federal Police	Police
	• National Measurement Institute	Science
New South Wales	• New South Wales Health Pathology	Health
	• New South Wales Police Force	Police
Northern Territory	• Northern Territory Police	Police
Queensland	• State of Queensland acting through Queensland Health	Health
	• Queensland Police Service	Police
South Australia	• Forensic Science South Australia	Justice
	• South Australia Police	Police
Tasmania	• Forensic Science Service Tasmania	Health
	• Tasmania Police	Police
Western Australia	• ChemCentre Western Australia	Science
	• PathWest Laboratory Medicine, Western Australia	Health
	• Western Australia Police	Police
Victoria	• Victorian Institute of Forensic Medicine	Justice
	• Victoria Police	Police
New Zealand	• Institute of Environmental Science and Research Limited	Science
	• New Zealand Police	Police

as forensic capabilities within the Defence Department, who investigate military-related crime.

Almost all forensic service providers in Australia are accredited to ISO 17025 through the National Association of Testing Authorities (NATA), Australia's government-recognized accreditation body. The Institute of Environmental Science and Research Limited (ESR) is accredited to ISO 17025 through the American National Standards Institute (ANSI) National Accreditation Board (ANAB). Another major stakeholder in forensic science is the Australian Criminal Intelligence Commission (ACIC), who, among other services, maintains the national databases for DNA, fingerprints, and firearms. The main special interest groups are the Australia New Zealand Forensic Science Society (ANZFSS), open to all persons with an interest in forensic science; and the Australian Academy of Forensic Science (AAFS), a society that provides a bridge between forensic science and the judiciary. Membership in the AAFS is by invitation. The ANZFSS operates a major biennial international symposium, providing an excellent opportunity to showcase research in Australia New Zealand and bring information on international research initiatives to the region.

Australia New Zealand also engages on the international stage through the International Forensic Strategic Alliance (IFSA). IFSA is a multilateral partner-ship

between regional networks of operational forensic laboratories across the globe, whose mission is to create opportunities for strategic collaboration across the global forensic science community. Current IFSA work areas include the development of Minimum Requirements Documents (MRDs), a globally agreed Research and Innovation Position Statement and improving network communication. MRDs have been published for Forensic DNA Analysis, Seized Drug Analysis and Crime Scene Investigation and the following MRDs are in development: Digital and Multimedia Analysis, Questioned Documents, Latent Prints, and Toxicology [4].

Major Activities and Projects

Cross-jurisdictional, collaborative work is facilitated through ANZPAA NIFS, with the overall vision and major focus areas (*see* **Table 2**) articulated in the ANZPAA NIFS Strategic Plan 2019–22 [5] and with specific activities and projects detailed in the annual ANZPAA NIFS Business Plans [6]. The Strategic Plan is approved by the ANZPAA Board, while the Business Plan is approved by ANZFEC. Quarterly reporting monitors performance against the Business Plan to ANZFEC and the ANZPAA Board [2].

The ANZPAA NIFS work program reflects the agreed priorities of the forensic science community, and the Australia and New Zealand government service providers engage at all levels in its delivery. Significant work in relation to research and innovation includes:

- An investigation of the current and emerging issues for forensic science service provision to look at the priority needs of forensic stakeholders and investigate where forensic disciplines could provide support [7];
- An examination of the current research being undertaken in the Australia New Zealand community by academia, forensic science service providers, and by other science/research bodies [8];
- Development of a Research and Innovation Strategy to provide a mechanism to facilitate funding forensic research [9];
- Development of a Research and Innovation Roadmap to guide future investment in forensic science across Australia and New Zealand [10]; and
- Publication of specific annual research questions from which a research project could be developed [11].

The Roadmap and annual questions are developed in consultation with government service providers, academia, research agencies and end users. The results are promoted through networks and academic institutions to stimulate the development of operationally relevant research. The information is also published online.

Validity and reliability of forensic evidence continues to be a major theme of work at the cross jurisdictional level in Australia and New Zealand. A continuing major project in this area concerns Forensic Fundamentals, that is, the validation of the science underpinning forensic disciplines [12–13]. Important work in relation to Forensic Fundamentals includes:

Table 2. ANZPAA NIFS focus areas

Focus area	Description
Coordination	Builds current jurisdictional and cross-jurisdictional operational capability and effectiveness through protocols, products, and enhanced implementation support
Innovation	Contributes to a creative and innovative forensic science body of knowledge and enhances the way we assess, adopt, and implement new forensic capabilities and tools
Information management	Promotes and facilitates information-sharing and cross-jurisdictional dialogue and events
Education and training	Maximizes opportunities for forensic science skills and knowledge development
Quality	Delivers quality assurance programs, develops standards, and manages the practitioner certification program

- A Guideline to Forensic Fundamentals considering what is meant by foundational validity (underpinning science considerations) and validity as applied (implementation considerations) [14];
- An Empirical Study Design in Forensic Science Guideline aimed at providing an agreed position on the components of a good quality empirical study [15]; and
- Analyses of the underpinning science for bloodstain pattern analysis, shoemarks, document examination, anthropology, firearms, fingerprints, explosives, toxicology, and gunshot residue, and the identification of the areas for improvement and the priority research areas.

National Consistency

Important to any cross-jurisdictional service delivery model are standardized procedures and methods. ANZPAA NIFS has facilitated the development of numerous guidelines and documents to enhance standardized practice compliant to internationally agreed procedures [16]. Documents published include:

- A Multidisciplinary Approach to Crime Scene Management;
- An Introductory Guide to Evaluative Reporting, Fact Sheet and Poster;
- Australia and New Zealand Guidelines for Digital Imaging Processes — 2013;
- Australia and New Zealand Police Recommendations for CCTV Systems — 2014;
- Case Record Review in Forensic Biology;
- Double Blind System Testing — A Model Framework for Forensic Science Laboratories;
- Facial Identification — Glossary of Terms;
- Familial DNA Searching Fact Sheet;
- The Intelligent Use of Forensic Data; and
- Transitioning Technology from the Laboratory to the Field — Process and Considerations for the Forensic Sciences.

Nationally agreed training facilitates cross-jurisdictional interoperability, resource movement, and surge capability required for collaborative responses to major incidents, such as mass casualty incidents. ANZPAA NIFS work in this area includes:

- Facilitate cross-agency education and training workshops to address critical training needs;
- Develop national qualifications for Forensic Investigation, Crime Scene Investigation, Fingerprint Investigation and Firearms Examination [17];
- ANZPAA Education and Training Guidelines that have been mapped, and are equivalent, to the national qualifications;
- ANZPAA education and training guidelines for crash investigation, document examination, clandestine laboratories, technology crime, and audiovisual examination;
- National training curricula to articulate the specific deliverables for training in Fingerprints and Firearms; and
- Agreed training standards for bloodstain pattern analysis.

Quality-Related Activities

ANPZAA NIFS also runs, through the AFSAB Board, the AFSAB certification program which promotes the professionalism of forensic examiners and enhances confidence in the competency of practitioners by the police and the courts. AFSAB assesses the competency of practitioners that meet prerequisite requirements using a written, practical and oral examination process. Practitioners are then monitored through regular revalidation that examiners maintain competence and reviews practitioners to ensure compliance with the established professional standards [18]. Every five years an in-depth revalidation occurs to ensure continued competency and professional development. There are currently 392 practitioners from all Australian jurisdictions; crime scene (95), fingerprints (264) and firearms (33) certified under the AFSAB program. ASFAB is underpinned by a Code of Ethics and Professional Conduct that practitioners must adhere to. The AFSAB processes include the use of independent assessors, a grievance and appeals process, confidentiality agreements, conflict of interest declarations and no fees. AFSAB certification allows for professional breaks and includes a process for revocation of certification if required [18].

ANZPAA NIFS has played an integral role in the development of the Australian and ISO standards, through the Australian standards development body, Standards Australia (SA). An ANZPAA NIFS representative chairs the SA and ISO committees, facilitating input into their development. The development of forensic standards is important to ensure that forensic services are delivered in accordance with a community- and stakeholder-defined level of quality. Forensic standards are documents that specify the quality requirements for forensic services and in doing so provide guidance to the forensic provider in how to deliver the product or service to that benchmark [19,20]. To date Australia has developed seven forensic science standards through Standards Australia Committee CH041-Forensic Analysis, including AS 5239-2011: Examination of ignitable liquids in fire debris; AS 5388.1-4: Forensic analysis series of four standards; and AS 5483-2012: Minimizing the risk of contamination in products used to collect and analyse biological material for forensic DNA purposes [19,20].

ANZPAA NIFS has been running a proficiency-testing program for Australia New Zealand since 1992, coordinating the purchase of hundreds of proficiency tests from various Australian and international suppliers. Participation in proficiency testing is an important element of any accreditation program. ANZPAA NIFS coordination of the proficiency-testing program provides a cost-effective mechanism, resulting in significant savings for laboratories to access the tests and an ability to compare performance between laboratories [21–22]. ANZPAA NIFS maintains proficiency test records for the laboratories and an analysis of these results enables laboratories to identify potential systematic issues and critical process points subject to errors. The analysis can also inform decisions regarding appropriate training or improvements to procedures or quality systems.

Crime scene analysis is an area where commercially produced proficiency tests do not exist. For this reason, ANZPAA NIFS has been delivering, under the supervision of CSPAC, an annual online proficiency test since 1996. Two proficiency tests have routinely been developed each year, one for major/complex crime (for example, murder or sexual assault) and one for volume crime (for example, burglary or motor vehicle theft). The proficiency test known as "After the Fact" is taken online, where participants navigate through a scene, collecting evidence and taking notes and photographs [23–25]. Approximately 50 scenarios have been developed to date, with 18 currently available online. Each year approximately 350-400 practitioners participate in the testing over a six-week assessment period.

The Australia New Zealand environment delivers excellent opportunities for government service providers to collaborate and coordinate collective resources to deliver outcomes. ANZPAA NIFS provides dedicated resources and funding to facilitate and drive improvements and innovation in forensic science. ANZPAA NIFS maximizes the ability to reduce risk by facilitating standardization across agencies and to achieve cross-jurisdictionally agreed positions and responses to emerging issues. By connecting agencies and individuals (nationally and internationally)

to provide the right information, ANZPAA NIFS reduces duplication of efforts and time to deliver outcomes. ANZFEC governance plays a significant role in providing a process to implement outcomes and effect change.

Acknowledgments

The author would like to thank the ANZPAA teams and the ANZPAA NIFS stakeholders who collaborated to deliver the work described in this paper.

References

1. Ross A: Australian New Zealand Policing Advisory Agency National Institute of Forensic Science (ANZPAA NIFS) — the first 21 years; A*ust J Forensic Sci* 44:319; 2012.
2. Wilson-Wilde L: The future of the National Institute of Forensic Science — Implications for Australia and New Zealand; *Aust J Forensic Sci* 49:1; 2017.
3. ANZPAA NIFS Groups Terms of Reference; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2019; *http://www.anzpaa.org.au/forensic-science/resources/sags* (Accessed October 8, 2020).
4. International Forensic Strategic Alliance; IFSA; *https://www.ifsa-forensics.org/* (Accessed October 9, 2020).
5. ANZPAA NIFS Strategic Plan 2019–22; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2019; *https://www.anzpaa.org.au/forensic-science/our-work/products/publications* (Accessed October 10, 2020).
6. ANZPAA NIFS Business Plan 2020–21; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2020; *https://www.anzpaa.org.au/forensic-science/our-work/products/publications (*Accessed October 10, 2020).
7. Current and Emerging Issues in Forensic Science Service Provision; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2016; *http://www.anzpaa.org.au/forensic-science/our-work/products/publications (*Accessed October 8, 2020).
8. Current Status Report: Forensic Science Research and Innovation, Australia and New Zealand; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2017; *http://www.anzpaa.org.au/forensic-science/our-work/products/publications (*Accessed October 8, 2020).
9. Research and Innovation Strategy 2017–20; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2017; *http://www.anzpaa.org.au/forensic-science/our-work/products/publications* (Accessed October 8, 2020).
10. Research and Innovation Roadmap 2017–21; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2017; https://www.anzpaa.org.au/forensic-science/our-work/products/publications (Accessed October 8, 2020).
11. Research and Innovation Roadmap — 2020 Annual Projects; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2020; *https://www.anzpaa.org.au/forensic-science/our-work/projects/research-and-innovation-project* (Accessed October 8, 2020).
12. Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods; [US] President's Council of Advisors on Science and Technology: Washington DC; 2016.
13. Ballantyne KN, Wilson-Wilde L: Assessing the reliability and validity of forensic science — An industry perspective; *Aust J Forensic Sci 5*2:1; 2020.
14. A Guideline to Forensic Fundamentals: Identifying the underpinning science of human-based forensic science disciplines; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2016; *http://www.anzpaa.org.au/forensic-science/our-work/products/publications (*Accessed October 8, 2020).
15. Empirical Study Design in Forensic Science; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2019; *http://www.anzpaa.org.au/forensic-science/our-work/products/publications (*Accessed October 8, 2020).
16. Accurate Science Requires That We Base Our Work on Accurate Publications; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2020; *http://www.anzpaa.org.au/forensic-science/our-work/products/publications* (Accessed October 8, 2020).
17. Police Training Package; Australian Industry Standards: South Melbourne, Australia; 2020; *https://www.australianindustrystandards.org.au/training-packages/police-training-package/* (Accessed October 9, 2020).
18. Australasian Forensic Sciences Assessment Body Policy and Processes for Certification — June 2020; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2020; *http://www.anzpaa.org.au/forensic-science/resources/afsab* (Accessed October 8, 2020).
19. Wilson-Wilde L: The international development of forensic science standards — A review; *Forensic Sci Int* 288:1; 2018.
20. Robertson J, Kent K, Wilson-Wilde L: The development of a core forensic standards framework for Australia; *Forensic Science Policy & Management An International Journal* 4:59; 2013.
21. Wilson-Wilde L, Smith S and Bruenisholz E: The analysis of Australian proficiency test data over a ten-year period; *Forensic Science Policy & Management An International Journal* 8:55; 2017.
22. Wilson-Wilde L, Romano H, Smith S: Error rates in proficiency testing in Australia; *Aust J Forensic Sci* 51(sup1):S268; 2019.
23. After the Fact; National Institute of Forensic Science, Australia New Zealand Policing Advisory Agency: Melbourne, Australia; 2020; *https://www.anzpaa.org.au/forensic-science/resources/atf* (Accessed October 8, 2020).
24. After the Fact 2020; 2020; *https://www.webatf.com/* (Accessed October 9, 2020).
25. Smith S, Wilson-Wilde L: Ten years of the after the fact crime scene proficiency test; Poster presentation — *The Australian and New Zealand Forensic Science Society 24th International Symposium*; Perth, West Australia, Australia; September 9–13; 2018.

Forensic Science Educational Programs (VII) — Programs in Mexico and Canada[a]

Qiana Staton-Vega[1], Corianne A. Rarrick[1]
Ubicelio Martin Orozco[2], Elizabeth A. Gardner[1]*

[1]*Department of Criminal Justice*
University of Alabama at Birmingham
Birmingham, Alabama
United States of America
+1 205 934 0668; eagard@uab.edu

[2]*Department of Veterinary Sciences*
Autonomous University of Ciudad Juárez
Ciudad Juárez, Chihuahua
México

Higher education was established in Mexico in the 16th century, prior to the first colleges in the rest of North America. The Real y Pontificia Universidad de México (Royal and Pontifical University of Mexico) in Mexico City was founded by royal decree in 1551. The earliest colleges in the United States (Harvard College in Cambridge, MA) and Canada (the Université Laval in Québec) were founded in 1636 and 1663, respectively.

However, courses in forensic science are relatively new in Mexico. The international popularity of TV crime shows in the 21st century has sparked a surge of interest in forensic science degrees. In 2013, the Universidad Nacional Autónoma de México (National Autonomous University of Mexico) in Mexico City established the nation's first master's degree in forensic science [1]. Many universities have since followed with certificate programs as well as bachelor's, master's, and doctoral degree programs (Table 1). This academic surge paralleled a vast increase in the nation's need for qualified forensic scientists. In 2018, it was estimated that it would take 4,000 new forensic scientists to meet the requirements of the Fiscalía de la República (Office of the Public Prosecutor) [2].

Universities in Mexico are registered with the Secretariat of Public Education (SEP) of the federal government, rather than accredited. Individual programs can be evaluated and awarded Recognition of Official Validity of Studies (RVOE) under SEP [3]. However, official validity is not synonymous with accreditation. The most prestigious recognition is awarded by the National Council for Science and Technology (CONACYT) with the National Register of Quality Graduate Programs (PNPC) [4]. While private universities can register with SEP, the Federation of Private Mexican Institutions of Higher Education (FIMPES) began accrediting private universities in 1994.

While TV crime shows are just as popular in Canada as Mexico and the United States, it doesn't seem to have sparked a similar explosion of academic programs. As in Mexico, there is not a national system of accreditation in Canada; however, Universities Canada is an organization of universities that have strict criteria of institutional quality assurance to be eligible for membership. Consequently, some universities will apply to US accreditation agencies. Of the programs listed (Table 2), two are accredited by the Forensic Science Education Programs Accreditation Commission [5] in the United States. Degrees are offered at the certificate, bachelor's, and master's levels (Table 2). An honors degree is expected to include more advanced courses and is completed in four years, as opposed to the general bachelor's degree that can be completed in three. An honors degree is recommended for continuing to an advanced degree. A combined degree can be either interdisciplinary or international.

If your university was missed in this listing, please contact Dr. Elizabeth Gardner, eagard@uab.edu, to ensure that it is included in the next version.

References

1. Cullell JM: La vocación forense en el país de los 3,7 homicidios por hora (The forensic discipline in the country with 3.7 homicides per hour); *https://elpais.com/internacional/2018/10/13/mexico/1539386146_581548.html* (Accessed October 14, 2020).
2. *http://www.cua.uam.mx/news/miscelanea/los-nuevos-peritos-mexicanos-se-enfrentan-a-un-escenario-laboral-desbordado-por-la-violencia* (Accessed October 24, 2020).
3. *https://www.gob.mx/sep/acciones-y-programas/reconocimiento-de-validez-oficial-de-estudios-rvoe* (Accessed November 8, 2020).
4. *https://www.conacyt.gob.mx/index.php* (Accessed November 8, 2020).
5. *https://www.fepac-edu.org/* (Accessed October 24, 2020).

[a]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 responses — mostly requesting minor revisions of entries.

Table 1. Forensic science university degrees in Mexico

Institution[a]; City, State; Department; URL	Contact information[b]	Program emphasis	Degree[a,c]	Accred.[d]
Benemérita Universidad Autónoma de Puebla Puebla, Puebla School of Medicine *https://medicina.buap.mx/?q=content/licenciaturas*	Jaime Tepoz Martínez; +52 2 29 55 00 (×6098); drjtepozforense@hotmail.com	Forensic sci.	BS	SPU
Centro de Estudios Superiores en Ciencias Mexico City, Mexico Jurídicas y Criminológicas *http://www.cescijuc.com/doctorado-ciencias-forenses*	+52 5709 9188; contacto@cescijuc.com[b]	Forensic sci. Criminal inv. in forensic sci.	PhD MS, BS	Fed./RVOE Fed./RVOE
Centro De Estudios Universitarios Vizcaya de las Américas Uruapan, Michoacan Health *https://www.uva.edu.mx/Uruapan/Criminologia-y-ciencias-forenses*	+52 452 114 21 98; reports@uva.edu.mx	Criminology & forensic sci.	MS	State/RVOE
Centro Educativo Superior Zapotlãn Ciudad Guzmán, Jalisco *http://cappza.com/centroeducativosuperior/eventos-2/*	+52 341 413 1355[b]	Legal psychol., criminology & forensic sci.	MS	State/RVOE
Centro Universitario de Cd. Juárez Juarez, Chihuahua *https://cucjonline.com/*	+52 656 566 – 0364[b]	Criminalistics (online) Forensic sci.	MS CTF	State/RVOE State/RVOE
Centro Universitario De Tijuana Mexicali, Baja California Social Sciences — Administration and Law *https://udetijuana.edu.mx/ciencias-forenses/*	+52 686 567 3014[b]	Forensic sci.	BS	State/RVOE
Colegio Libre De Estudios Universitarios Uman, Yucatan Technology of the Information and Communication https://www.cleu.edu.mx/Campus/CampusMerida/LicenciaturaComputoForense	+52 01 999 252 01 55 (×101)[b]; incorporacion.merida@cleu.edu.mx	Computer forensics & cyber security	BS	Fed./RVOE
Colegio Libre De Estudios Universitarios Puebla, Puebla Health *https://www.cleu.edu.mx/Campus/CampusPuebla/MaestriaenMedicinaForense*	+52 222 285 6213; incorporacion.puebla@cleu.edu.mx	Forensic med. Forensic valuation	MS MS	State/RVOE RVOE
Escuela Juridica y Forense del Sureste Nezahualcoyotl, Mexico *https://web.ejfs.edu.mx/*	+52 55 54 28 35 04[b]	Criminalistics & oral trials	BS	Fed./RVOE
Escuela Mexicana De Puebla Tlaxcala, Tlaxcala Social Sciences — Administration and Law *https://www.escuelamexicana.net/*	+52 246 144 26 34[b]	Forensic & expert sci.	BS	State/RVOE
Escuela Nacional de Antropología e Historia Mexico City, Mexico *https://enah.edu.mx/index.php/ofer-aca/esp-for*	+52 55 5666-3454 (×411993); antropologiaforense_enah@inah.gob.mx	Forensic anthropol.	CTF	FPU
Instituto de Ciencias Forenses y Criminológicas Aguascalientes, Aguascalientes *http://icfc.com.mx/?page_id=10*	+52 449-144-5001 contacto@icfc.com.mx	Criminalistics & crim. inv.	BS	State/RVOE
Instituto de Ciencias Forenses y Periciales Puebla, Puebla Health *www.cfp.edu.mx*	+52 01 222 237 5514[b]	Forensic & legal med.	MS	State/RVOE
Instituto De Criminologia Y Ciencias Penales del Noroeste A.C. Culican, Sinaloa Social Sciences — Administration and Law *http://institutodecriminologiasinaloa.edu.mx/*	+52 667 712 3993[b]; contacto@institutodecriminologia.com	Forensic crime	MS	State/RVOE

Table 1. Continued

Institution[a]; City, State; Department; URL	Contact information[b]	Program emphasis	Degree[a,c]	Accred.[d]
Instituto de Estudios Tecnológicos y Superiores Matatipac Tepic, Nayarit *https://portal.institutomatatipac.edu.mx/maestria-en-criminologia-y-ciencias-forenses/*	+52 311 216 9000[b]; informes@institutomatatipac.edu.mx	Criminology & forensic sci. Security & forensic sci.	BS BS	
Instituto de Formación Académica del Centro y Sureste Plantel, Chiapas *http://www.infa.edu.mx/Pantropologia.html*	+52 6146688[b]	Forensic anthropol.	CTF	State/RVOE
Instituto Mercurio Tepic, Nayarit Social Sciences — Administration and Law *https://www.institutomercurio.edu.mx/ciencias-forenses/*	+52 311 213 5926; admin@institutomercurio.edu.mx	Forensic sci.	MS	State/RVOE
Instituto Nacional de Desarrollo Jurídico Mexico City, Mexico *http://inadej.edu.mx/courses/maestria-en-ciencias-penales-2/* *http://inadej.edu.mx/courses/licenciatura-en-ciencias-forenses-3/*	+52 55 5536 1584[b]	Criminal sci. Forensic sci.	MS BS	Fed./RVOE
Instituto Forense De Investigaciones Latino Americana Coatzacoalcos, Veracruz Social Sciences — Administration and Law *https://www.ifil.mx*	+52 921 218 40 34; ifilcoatza@hotmail.com	Forensic sci. & criminalistics	MS	State/RVOE
Instituto Politecnico Nacional Mexico City, Mexico School of Medicine *https://www.sepi.esm.ipn.mx/oferta-educativa/especialidad-medicinaforense/*	M en C. Jaime Cárdenas Camacho; +52 51 34 13 63; jacar91@hotmail.com	Forensic med.	CTF	FPU[e]
Instituto Universitario de Ciencias Toluca, Mexico *http://www.fermento.mx/*	+52 722 212 2130; correo@iuc.mx	Forensic sci.	BS	Fed./VROE
Instituto Universitario Gueburah Puebla, Puebla Social Sciences and Law *http://www.iugueburah.edu.mx/index.php/licenciaturas-en-puebla/licenciatura-en-ciencias-forenses-en-puebla-universidad.html*	+52 222 625 3903	Forensic sci.	BS	Fed./RVOE
Instituto Universitario Del Pacifico Tepic, Nayarit Social Sciences — Administration and Law *http://www.universidaddelpacifico.com.mx/Universidad/*	+52 311 220 30 11	Forensic sci.	BS	State/RVOE
Instituto Universitario Puebla Villahermosa, Tabasco Social Sciences and Law *https://iupsureste.mx*	+52 993 139 9042	Criminalistics & forensic sci.	MS	State/RVOE
Instituto Zacatecano De Estudios Universitarios (IZEU) Guadalupe, Zacatecas Social Sciences — Administration and Law *http://www.izeu.edu.mx/maestria-en-ciencias-forenses/*	+52 899 17 40; vinccion.izeu@hotmail.com	Forensic sci.	PhD, MS, BS	State/RVOE
Instituto De Zumpango En Zumpango, Mexico Estudios Superiores En Criminalistica (IZESC) Social Sciences and Law *https://izesc.edu.mx/criminalistica-y-ciencias-forenses/*	+52 01591 611 4706; info@izesc.edu.mx	Criminalistics & forensic sci.	BS	Fed./RVOE
Universidad Autónoma de Durango Durango, Durango *http://uadlobos.mx/ciencias-forenses-y-victimologia-maestrias-durango.html*	+52 618 129 5786[b]	Forensic sci. & victimology	MS	State/RVOE

Table 1. Continued

Institution[a]; City, State; Department; URL	Contact information[b]	Program emphasis	Degree[a,c]	Accred.[d]
Universidad Autonoma De Guadalajara Villahermosa, Tabasco Social Sciences and Law *http://tabasco.uag.mx/Universidad/Posgrado/Salud-Maestria-Ciencias-Forenses#services*	+52 993 310 5170; promocion1@uagtabasco.edu.mx	Forensic sci.	MS	State/RVOE
Universidad Autónoma de Tamaulipas Reynosa, Tamaulipas Division of Postgraduate Studies and Research *https://uat.edu.mx*	Karla Villarreal Sotelo; +52 9213300 (×8413); kvillar@uat.edu.mx	Criminology & forensic sci.	MS	SPU/**PNPC**
Universidad Autónoma de Sinaloa Culiacán Rosales, Sinaloa Unit of Criminalistics and Forensic Sciences *https://www.uas.edu.mx/*	+52 667 7593828[b]	Criminalistics & forensic sci.	BS	SPU
Universidad Durango Santander Hermosillo, Sonora Social Sciences — Administration and Law *http://www.uadlobos.mx/ciencias-forenses-y-victimologia-maestrias-hermosillo.html*	+52 662 210 5009	Forensic sci. & victimology	MS	State/RVOE
Universidad de España y México Mexico City, Mexico *https://uem.edu.mx/licenciaturas/licenciatura-en-criminologia-y-criminalistica/*	+52 5552079020[b]	Criminology & criminalistics	BS	
Universidad de Guadalajara Tonalá, Jalisco University Center of Tonalá *http://www.cutonala.udg.mx/oferta-academica/ciencias-forenses*	Alma Cristina Padilla de Anda; +52 33 20 00 23 00 (×64115); cd.forenses@cutonala.udg.mx	Forensic sci.	BS	SPU
Universidad de LaSalle Bajío León, Guanajuato Facultad de Derecho *http://bajio.delasalle.edu.mx/oferta/oferta5.php?n=6&p=56*	+52 477 710 85 00 (×1241)[b]	Forensic sci.	MS	Fed./RVOE FIMPSE
Universidad de Matehuala Matehuala, San Luis Potosi Ciencias Sociales, Administración y Derecho *https://www.unimatehuala.edu.mx/maestriaencienciasforenses.html*	+52 01 488 88 2 54 05[b]	Forensic sci.	Cert.	State/RVOE
Universidad Nacional Autónoma de México Mexico City, Mexico School of Medicine *http://www.cienciaforense.facmed.unam.mx/*	Zoraida García Castillo; +52 56224210 (×4215); zoraidagc@unam.mx	Forensic sci.	BS	FPU
Universidad de Oriente Puebla, Puebla Ciencias Sociales, Administración y Derecho *https://www.uo.edu.mx/maestrias/ciencias-forenses-y-periciales-en-puebla*	+52 2223244141[b]	Forensic sci. & expertise	MS	State/RVOE
Universidad Popular Autónoma de Veracruz Xalapa-Enríquez, Veracruz *https://www.upav.edu.mx/posgrados/m-criminalistica-e-investigacion-forense*	+52 228 8 173410; dept.posgrados@upav.edu.mx	Criminalistics & forensic inv.	MS	State/RVOE
Universidad Salazar Tuxtla Gutiérrez, Chiapas *http://www.iesch.edu.mx/?s=informacion&tok=160451628416*	+52 961 614 16 21[b]	Forensic sci.	MS	State/RVOE
Universidad de Tijuana Tijuana, Baja California *https://udetijuana.edu.mx/ciencias-forenses/*	+52 664 6879454[b]; contacto@iesch.edu.mx	Forensic sci.	BS	State/RVOE

Table 1. Continued

Institution[a]; City, State; Department; URL	Contact information[b]	Program emphasis	Degree[a,c]	Accred.[d]
Universidad Veracruzana Boca del Río, Veracruz Forensic Medicine *https://www.uv.mx/veracruz/mmf/*	Patricia Beatriz Denis Rodríguez; +52 229 7752000 ((×22011)[b]; pdenis@uv.mx	Forensic med.	MS	SPU/**PNPC**
Universidad Vizcaya De Las Americas Tepic, Nayarit Social Sciences — Administration and Law *https://www.uva.edu.mx/Tepic/Criminologia-y-ciencias-forenses*	+52 311 213 69 00; informes@uva.edu.mx	Criminology & forensic sci.	MS	State/RVOE
Universidad Villa De Zacatecas Guadalupe, Zacatecas Health *https://universidadvilladezacatecas.edu.mx/licenciatura-en-ciencia-forense/*	+52 492 156 0421; contacto@uvz.edu.mx	Forensic sci.	BS	State/RVOE

[a] Institution name in bold indicates a top 20 university in Mexico, as rated by UniRank, an international higher education directory and search engine (*https://www.4icu.org/mx/*). Institution with RVOE designated programs were only included if an active program was listed in the university web pages.
[b] Admission or school contact information, no specific person contact information given.
[c] Abbreviations for degrees and certificates: BS = Bachelor of Science; MS = Master of Science; PhD = Doctor of Philosophy; CTF = Certificate for a one-year course of postgraduate study.
[d] Abbreviations for registrations: Fed./RVOE: RVOE recognition at the federal level; FIMPSE: Federation of Private Mexican Institutions of Hugher Education; FPU: Public university registered with SEP at the federal level; PNPC: Padrón Nacional de Postgrados de Calidad (National Register of Quality Postgraduate programs), degree rated as a quality postgraduate program by CONACYT (National Council for Science and Technology); ROVE: Recognition of Official Validity of Studies; SPU: Public university registered with SEP at the state level; State/RVOE: RVOE recognition at the state level.
[e] In the process of applying for PNPC.

Table 2. Forensic science university degrees in Canada

Institution[a]; City, State; Department; URL	Contact information[b]	Program emphasis	Degree[a,c]	Accred.[d]
British Columbia Institute of Technology Burnaby, British Columbia School of Computing and Academic Studies *https://www.bcit.ca/computing-academic-studies/forensics/*	David McKay; +1 (604) 432-8238; David_McKay@bcit.ca	Biochem. & forensic sci. Digital forensics & cyber security Crime and intelligence analysis Forensic sci. Fraud & financial crime	BS (Hon)/UBC[e] BTech, Adv CTF BTech, Adv CTF BTech, Grad CTF Prof Dev	
Humber Institute of Technology & Advanced Learning Toronto, Ontario Social & Community Services *https://communityservices.humber.ca/programs/forensic-identification.html*	Debbie Harris; +1 (416) 675-6622 (×3028); debbie.harris@humber.ca	Forensic ident.	Grad CTF	
Lambton College Sarnia, Ontario International Programs *https://www.lambtoncollege.ca/custom/LambtonApps/Programs/International.aspx?id=2147513852*	+1 (519) 541-2403[b]; international@lambtoncollege.ca[b]	Cyber security & computer forensics	Grad CTF	
Laurentian University Sudbury, Ontario Department of Forensic Science *https://laurentian.ca/program/forensic-science*	James H. Watterson; +1 (705) 675-1151 (×4349); forensic_advising@laurentian.ca[b]	Forensic sci. Forensic ident.	MS (Hon), **BS (**Hon**)**, **BS** (Hon)/Chem. BS (Hon)/Bio., minor, CTF	UC **FEPAC**
Ontario Tech University Oshawa, Ontario Faculty of Science *https://ontariotechu.ca/programs/science/forensic-science.php*	C. Hageman; +1 (905) 721-8668 (×2128); cecilia.hageman@ontariotechu.ca	Forensic sci. specialty in bio., chem., or phys.	**BS (Hon)**	**FEPAC**

Table 2. Continued

Institution[a]; City, State; Department; URL	Contact information[b]	Program emphasis	Degree[a,c]	Accred.[d]
Saint Mary's University Halifax, Nova Scotia Faculty of Science *https://smu.ca/academics/departments/forensic-science.html*	+1 (902) 420-5661[b]; advisor.science@smu.ca[b]	Forensic sci.	CTF	UC
Simon Frasier University Burnaby, British Columbia. Faculty of Arts and Social Sciences *https://www.sfu.ca/students/admission/programs/a-z/f/forensic-studies/overview.html*	Morgan Jeffery; +1 (778) 782-7800; crimbby@sfu.ca	Forensic studies	CTF	UC
Trent University Peterborough, Ontario Department of Forensic Science *https://www.trentu.ca/forensicscience/*	Christopher Kyle; +1 (705) 748-1011 (×7200); forensicscience@trentu.ca	Forensic sci. Forensic bio. Forensic chem. Joint major in forensics	MS, BS (Hon) BS BS BA or BS	
Université du Québec à Trois-Rivières Trois-Rivières, Québec *https://oraprdnt.uqtr.uquebec.ca/pls/apex/f?p=106:10:::::10:P10_CD_PGM,P10_RECH_CRITERE,P10_RECH_VALEUR,P10_RECH_DESC:6544,P2_CD_NIVEAU,BACC,%5CBaccalaur%C3%A9ats%20et%20doctorats%20de%20premier%20cycle%5C*	Benoit Daoust; +1 (819) 376-5011 (×3325); dir.prem.cycle.scp@uqtr.ca	Forensic sci.	BS	UC
University of British Columbia Vancouver, British Columbia Department of Biochemistry UBC[d] Science *https://science.ubc.ca/students/programs/forensic-science* *https://www.bcit.ca/study/programs/9940bsc#contacts*	Jason Moore; +1 (604) 451-7178; Jason_Moore@bcit.ca	Biochem. & forensic sci.	BS (Hon)/BCIT[e]	UC
University of Toronto — Mississauga Mississauga, Ontario Department of Forensic Science *https://www.utm.utoronto.ca/forensic/*	Teresa Cabral; +1 (905) 569-4455; teresa.cabral@utoronto.ca	Forensic sci. Forensic anthropol. Forensic bio. Forensic chem. Forensic psychol.	BS (Hon), minor Spec Spec Spec Spec	UC
University of Windsor Windsor, Ontario Faculty of Science *https://www.uwindsor.ca/science/368/bachelor-forensic-science*	Shashi K. Jasra; +1 (519) 253-3000 (×4583); sjasra@uwindsor.ca	Forensic sci. conc. in mol. bio. & chem.	BS (Hon), BA (Hon)/ social sci.	UC

[a] Programs (and the affiliated institutions) that are accredited by Forensic Science Education Programs Accreditation Commission (FEPAC) are presented in boldface.

[b] Admission or school contact information, no specific person contact information given.

[c] Abbreviations for degrees and certificates: Adv CTF = Advanced Certificate; BA = Bachelor of Arts; BS = Bachelor of Science; BTech = Bachelor of Technology; comb: Combined with; CTF = Certificate; Grad CTF = Graduate Certificate; Hon = Honours; MS = Master of Science; Prof Dev = Professional development; Spec = Specialist, a research-based BS.

[d] Abbreviations for registration and accreditation: FEPAC: Forensic Science Education Programs Accreditation Commission; UC: Member of Universities Canada.

[e] BCIT: British Columbia Institute of Technology; UBC: University of British Columbia.

Upcoming Events*

3rd Emirates International Forensic Conference and Exhibition (*https://emiratesforensic.ae/about/*)

Feb. 10–15, 2021; Dubai Int. Convention & Exhibition Centre
Dubai, UAE

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

Feb. 15–20, 2021; Virtual online meeting

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

March 8–12, 2021; Virtual Event
New Orleans, LA, US

International Conference on Forensic Science and Criminalistics (*https://waset.org/forensic-science-and-criminalistics-conference-in-march-2021-in-miami*)

March 11–12, 2021; Digital online meeting
Miami, FL, US

California Association of Criminalists—Spring Seminar
(*cacnews.org/events/seminar/seminarcurrent.shtml*)

April 19–23, 2021; Possible Virtual Workshops
Sacramento, CA, US

Southern Association of Forensic Scientists — Annual Meeting (*https://safs1966.org/annual-meeting/*)

April 26–30, 2021; The Lodge at Gulf State Park
Hilton Hotel Gulf Shores, AL, US

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

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

The Association of Firearm and Tool Mark Examiners — 52nd Annual Training Seminar
(*https://afte.org/meetings/annual-seminars*)

May 23–28, 2021; Hyatt Regency Miami
Miami, FL, US

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

May 25–28, 2021; Kalahari Resort & Convention Center
Pocono Manor, PA, US

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

Aug. 1–7, 2021; Gaylord Opryland Resort
Nashville, TN, US

American Society of Crime Laboratory Directors — 48th Annual Symposium
(*https://www.ascld.org/ascld-annual-symposium/*)

Aug. 22–26, 2021; The Westin Copley Place
Boston, MA, US

International Association of Chiefs of Police (IACP) 2021
(*https://www.theiacpconference.org/*)

Sept. 11–14, 2021; Ernest N. Morial Convention Center
New Orleans, LA, US

ISHI 32: International Symposium on Human Identification (*https://www.ishinews.com/ishi-32-to-be-held-in-orlando-florida/*)

Sept. 14–17, 2021; Coronado Springs Resort
Orlando, FL, US

IFDAT 2021: Annual International Forum for Drug & Alcohol Testing Conference
(*https://www.ifdat.com/*)

Sept. 19–21, 2021; Implauer Hotel
Salzburg, Austria

2021 International Conference on Forensic Nursing Science and Practice
(*https://www.forensicnurses.org/page/2020AnnualConference*)

Sept. 22–25, 2021 (Venue to be announced)
Orlando, FL, US

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

Sept. 26–Oct. 1, 2021; Gaylord Opryland Resort
Nashville, TN, US

SCIX 2021 — Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies
(*https://facss.org/event-3326055*)

Sept. 26–Oct. 1, 2021; Rhode Island Convention Center
Providence, RI, US

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

Sept. 27–Oct. 1, 2021; Kimpton Hotel Vintage
Portland, OR, US (2020 conference cancelled)

TIAFT 2021: Annual Meeting of The International Association of Forensic Toxicologists
(*https://tiaft2021.co.za/general-information/*)

Oct. 24–28, 2021; Cape Town Int. Convention Center
Cape Town, South Africa

69th ASMS Conference on Mass Spectrometry and Allied Topics
(*https://asms.org/conferences/annual-conference*)

Oct. 31–Nov. 4, 2021; Philadelphia Convention Center
Philadelphia, PA, US

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

Nov. 1–5, 2021; Newport Marriott
Newport, RI, US

*Organizers sponsoring these conferences/meetings continue to monitor possible restrictions that may be affecting gatherings in 2021.

A Landscape Study of Laboratory Information Management System for Forensic Crime Laboratories

Rebecca Shute, Jeri Ropero-Miller*

RTI International
Research Triangle Park, North Carolina
United States of America
jerimiller@rti.org

The NIJ Forensic Technology Center of Excellence (FTCoE) supports the implementation of new forensic technology and best practices through its efforts to advance technology, share knowledge, and address challenges. The FTCoE informs the community of emerging and value-adding technologies through resources available at no cost to the reader. The FTCoE's landscape studies serve as a key tool for forensic decision makers. A landscape study is a comprehensive overview of market participants and their products, including insight on features to inform purchasing decisions and future adoption. These documents are unbiased guides that assist the reader in selection and implementation of a product and in distilling insights from industry experts and technology end-users.

In fall 2020, the FTCoE published "*A Landscape Study of Laboratory Information Management Systems (LIMS)*", which gives a comprehensive look at the benefits of having a LIMS, the range of solutions available, and guidelines for successful LIMS implementation. LIMS are software that effectively manage sample/evidence flow within a laboratory and also generate associated data such as test results, procedures, and control and audit mechanisms to improve lab efficiency. Insights from the NIJ's *Report to Congress: Needs Assessment of Forensics Laboratories and Medical Examiner/Coroner Offices* helped lead the FTCoE to conduct this landscape study. Beyond its basic functions, LIMS vendors offer advanced features that provide significant benefits to improve the laboratory's internal operations and communications with stakeholders. However, these value-added features are not often widely implemented. For example, of approximately 90% of the publicly funded laboratories who use a LIMS, less than a third of them use LIMS functions that track criminal case status or interface with laboratory instrumentation.This landscape report provides crime laboratory directors, crime laboratory personnel, law enforcement agencies, prosecutors and defense attorneys, courts, and other stakeholders and end-users with the following:

- Background information on LIMS and their integration into the laboratory evidence-management process;
- The product landscape of select commercial off-the-shelf (COTS) LIMS products;
- Considerations for implementing or updating internally developed and COTS LIMS;
- Use profiles from end-users illustrating best practices and lessons learned from incorporating a LIMS into the laboratory workflow; and
- LIMS features that facilitate systems-based communications between crime laboratories and their stakeholders, such as tracking status of criminal cases and the associated lab work.

LIMS — and Their Key Features — Play Instrumental Roles in Forensic Crime Laboratories

As a key stakeholder in the criminal justice system, forensic laboratories must track, analyze, and report on evidence related to each request for service they receive. This is no easy task for laboratories: according to a 2014 survey by the US Department of Justice's Bureau of Justice Statistics (BJS), publicly funded crime laboratories received nearly 3.8 million requests for forensic services, with an average of 93,000 requests per laboratory [1]. The high number of caseloads necessitate the use of technology to ensure integrity of evidence is maintained and laboratories are operating efficiently.LIMS were developed to solve many of these challenges. LIMS enable the forensic laboratory to efficiently manage evidence and resources and can be scaled to meet the demands of federal, state, county, and municipal laboratories. The 2014 crime laboratory survey also shows that approximately 84% of crime laboratories use LIMS; more specifically, 97% of state laboratory systems, 76% of county laboratories, and 56% of municipal laboratories have LIMS [1].

While laboratories may use LIMS in different capacities, all LIMS are information management software products that offer a standard set of basic functions:

- **Document case-related information:** LIMS serve as a repository of data, including but not limited to case information for pieces of evidence, contextual and investigative information from the submitting agency, prescribed analytical methods, analysis preparation procedures, analyst notes, test results, quality control processes, records of evidence storage, retention, consumption, any relevant reports generated from the examinations, and chain of custody.
- **Manage laboratory processes and resources**: LIMS enable laboratory managers to view the entire crime laboratory's caseload or item load and the turnaround

time from receipt to reporting, and to manage QA processes such as a chain of technical and administrative review processes.
- **Enable data integrity and security:** LIMS protect the raw results from alteration after an analysis has been made, documents the analysis, and locks authorized data fields. LIMS allow laboratories to apply access restrictions to certain portions of the system depending on operational needs.
- **Generate internal and external reports**: LIMS reporting capabilities enable the lab to aggregate these insights and package relevant information for appropriate stakeholders. LIMS can also simplify the process of creating and sending these reports, offering pre-set or custom templates for reporting needs within and beyond the laboratory.

As laboratories have adopted LIMS, advanced features have enhanced the functionality and roles of such programs in the laboratory. These features include:

- **Streamlined communication abilities between agencies, laboratories, and courts:** LIMS can provide a means to communicate with criminal justice stakeholders through means such as pre-logging portals and interfacing capabilities with other data management systems.
- **Data aggregation for comparison, benchmarking, and trend analysis:** LIMS can gather data that can be used to inform the greater forensic community about important trends. This study provides an overview of the efforts of Project FORESIGHT [2] and the DEA's National Forensic Laboratory Information Systems (NFLIS) [3] to inform and improve laboratory operations.
- **Configurability to adapt to changing laboratory and stakeholder demands:** Some LIMS vendors offer a configurable, rather than a customizable, system, which gives appropriate laboratory staff the power to adjust these systems to their needs.
- **Supplies and consumables management system:** LIMS can help the laboratory easily understand current laboratory inventories, including expiration dates of reagents and other consumables to assist with supplies ordering and management.
- **Integration of new software products and technologies into the laboratory:** LIMS incorporate more and more functions and are becoming comprehensive "one-stop shops" for analysts.

Laboratories have several options to implementing LIMS that address their needs: vendors offer COTS products, or laboratories can develop their own systems to be as simple or complex as needed. This report breaks down advantages and disadvantages of both options and provides an overview of key features offered by a selection of major vendors in the LIMS space.

There are many commercially available LIMS, including systems that are built for case management within the medical examiner/coroner community, as well as systems that are built specifically for the workflows of certain disciplines, such as toxicology and DNA analysis. This landscape provides an overview of four commercially available products that develop products for the forensic crime laboratories that provide services across multiple disciplines: Abbott's STARLIMS, Forensic Advantage, JusticeTrax LIMS-plus, and Porter Lee's BEAST. These four products represented a selection of key market players chosen based on interviews with LIMS implementation experts, as well as literature such as publicly available crime laboratory LIMS manuals and the NFLIS-2019 Survey of Crime Lab Drug Chemistry Sections [4]. The study provides one-page overviews of each software product and examples of pricing for each vendor.

Forensic Laboratories Should Invest in Front-End Planning to Align Their LIMS to Their Needs

Adopting LIMS may be as disruptive and transformative as going through ISO 17025 accreditation and may reveal ambiguities in laboratory policies and expose inconsistencies in team practices.

Before implementing LIMS, laboratories must understand there is a significant amount of front-end planning and time necessary to design the software to their needs. Even if using a COTS LIMS, it must be refined for use in a specific laboratory. This planning process includes developing and understanding two key factors:

- **Needs of LIMS end-users:** Stakeholders in the criminal justice system use LIMS in a variety of different ways, depending on their role in the organization, and thus, they have different needs for a system. Decision makers must consider these stakeholders and their needs before implementing or significantly upgrading a LIMS. Key questions provided in the report are important to work through with all stakeholders, including laboratory leaders and practitioners, before choosing and implementing a LIMS. It is important to keep in mind that implementation is not merely an information technology (IT) project, and success hinges on the engagement of leadership and users throughout the process.
- **Business process workflows**: The business process workflow is defined as the means by which evidence flows through the forensic laboratory.Laboratories need to be sure that their LIMS align to the workflow or their workflow can accommodate predefined settings established by vendors. Changing business processes to conform to a well-established COTS LIMS can be challenging; however, laboratories should consider modifying or redefining workflows to COTS LIMS if they conform to established workflows set by the vendor. Each laboratory will have to determine if it can implement a COTS LIMS by configuring software options in combination with making changes to their business process workflow.

When implementing LIMS in a forensic laboratory, the report identifies lessons learned and best practices among experts to broaden an understanding in the selection or upgrade and implementation of LIMS. These insights include:

- **Identify key metrics and needs for LIMS reporting capabilities:** Laboratories can leverage LIMS to produce useful reports for internal and external stakeholders; however, the quality of these reports is directly related to the measures taken on the front end to ensure that the system is capturing the right information. Up-front planning is necessary to define business process workflows and understand how to best set up a system that addresses laboratory needs.
- **Understand the costs required for implementation**: LIMS implementation requires a significant amount of time and resources: deployment can take weeks to months, and setup costs can average around $4,000 per examiner and an additional $600/year for maintenance. No vendor offers a truly "turnkey" solution — regardless of what vendor or approach chosen, they require a considerable amount of up-front work to "build" these products to fit the needs of the laboratory.
- **Anticipate and allocate resources for internal or external IT support**: In addition to leaning on vendors for technology support, laboratories should consider allocating resources to hire in-house individuals with the skill sets to address LIMS maintenance.
- **Recognize the requirements to maintain interfacing systems**: Vendors are constantly updating and addressing bugs through software patches. Consequently, each software product must be updated and tested so that the systems will continue synchronizing with each other. This process takes a significant amount of time (both proactively and reactively), and this time burden can limit the value of integrating the systems.
- **Understand opportunities and limitations of "systems-based" communication between stakeholders:** While the addition of interfacing software tools and systems streamline processes and improve communication between stakeholders, maintaining these connections can be resource prohibitive. For example, coordinating LIMS and property and evidence-management systems (PEMS) for automatic data transfer could save time in the long run, but information flow between these systems may be interrupted when either systems are updated. Agencies should consider approaches to improved systems-based communication through a variety of means, including functions such as prelogging, which do not require application programming interfaces.
- **Appreciate agency policies and resources for procurement:** For implementing or developing new LIMS, laboratories should consider resources such as DOJ funding for support. The study provides an overview of sources laboratories can use for funding their LIMS.
- **Implement testing, training, and production processes**: To effectively roll out changes, laboratories should consider using separate testing, training, and production systems. This enables the crime laboratory to test LIMS in a safe environment to ensure that an upgrade will not cause a significant issue in the laboratory's operation. The study features a detailed timeline showing how a medium/large laboratory might implement a LIMS with the following stakeholders: LIMS Administrator or Tiger Team, β-Test Unit(s), all laboratory personnel, IT Team, COTS vendor/internally developed LIMS creator, submitting agencies/customers, and leadership.

In forensic laboratories, the value of LIMS goes beyond an information repository. Well-developed LIMS can play a major role in streamlining workflows, improving communication within the laboratory, identifying actionable insights, facilitating interaction between criminal justice stakeholders, and ensuring that evidence is properly managed and analyzed. Laboratories looking to update or implement LIMS can achieve these goals through pursuing COTS systems designed for forensic laboratories or can build these systems on their own and should consider literature such as the FTCoE's landscape study to help them accomplish this goal. You can find this study and more resources at *https://forensiccoe.org*.

References

1. Durose MR, Burch AM, Walsh K, Tiry E: *Publicly Funded Forensic Crime Laboratories: Resources and Services, 2014*; 2016; US Department of Justice (Office of Justice Programs): Washington, DC; 2016; *https://www.bjs.gov/content/pub/pdf/pffclrs14.pdf* (Accessed November 1, 2020).
2. Project FORESIGHT; West Virginia University: Morgantown, WV; 2020; *https://business.wvu.edu/research-outreach/forensic-business-studies/foresight* (Accessed November 1, 2020).
3. US Drug Enforcement Administration (Diversion Control Division): *National Forensic Laboratory Information System*; Springfield, VA; 2020; *https://www.nflis.deadiversion.usdoj.gov/* (Accessed November 1, 2020).
4. US Drug Enforcement Administration (Diversion Control Division): *NFLIS-Drug 2019 Survey of Crime Laboratory Drug Chemistry Sections Report*; Springfield, VA; 2000; *https://www.nflis.deadiversion.usdoj.gov/DesktopModules/ReportDownloads/Reports/13121NFLISdrugSurveyRpt6Nov29.pdf* (Accessed November 1, 2020).

The Ups and Downs of a Blind Quality Program — HFSC's Perspective

Erika Ziemak*, Callan Hundl, Carisa Martinez, Maddisen Neuman, Peter Stout

Houston Forensic Science Center
Houston, Texas
United States of America
+1 832-699-9137; eziemak@houstonforensicscience.org

The Houston Forensic Science Center (HFSC) emerged from the ruins of what had been the Houston Police Department's (HPD) scandal-ridden forensic services, a crime lab so infamous that news organizations repeatedly quoted a 2003 *New York Times* headline questioning whether it was the worst crime laboratory in the country [1]. The City of Houston, with HPD's support and guidance, created an agency whose very structure was designed to combat this reputation and build an agency that would not only excel in quality forensic science but become a model for the nation and the world. Houston created an independent local government corporation, a unique Texas quasigovernmental structure that allows an agency to provide services to a municipality under a separate corporate leadership.

This independence is responsive to the 2009 National Academy of Sciences report [2] on the state of forensic sciences and has allowed HFSC to forge a path of its own, separate from police and prosecutors and insulated from politics. HFSC is overseen by a nine-member board of directors made up of community volunteers appointed by the mayor and confirmed by the City Council. They are appointed for rotating two- and three-year terms but cannot be removed from their positions unless they commit a felony crime, and even then, removal requires City Council approval. This provides the board and HFSC with some insulation from politics and elections. The board from its inception has embraced quality and transparency as its guiding values, supporting innovative approaches to those values that have at times been met with skepticism. The end result, however, has been HFSC's ability to create programs and embark on projects that others might have viewed as too risky or too expensive. One of those programs is the blind quality control (BQC) program, which has grown to be the largest such enterprise in a forensic laboratory in the world, while the other is the monitoring of testimonies.

The Blind Quality Control (BQC) Program

The BQC program recently marked its five-year anniversary, a time span during which over 2,000 BQCs have been submitted. HFSC has spent those five years building this robust BQC program, designed to test laboratory workflows, processes, analyses, and the quality management system from start to finish. Now on the five-year anniversary of the program, with more than 2,000 submitted, we provide a look at the program's history, structure, benefits, challenges, and future endeavors.

The program was started in 2015 in the toxicology section and has since expanded to five of HFSC's other accredited disciplines: firearms, seized drugs, forensic biology, latent prints, and multimedia. The latent print and firearms sections also participate in the blind verification portion of the program. The only discipline that is not part of the program is the crime scene unit, because it is almost impossible to create a mock scene blind to investigators. The program is facilitated by HFSC's Quality Division, a seven-member team also responsible for facilitating the laboratory's open proficiency test program, leading the internal audit program, and ensuring that all accreditation requirements are fulfilled. While several members of the Quality Division participate in the creation, submission, and review of BQCs, one member of the team serves as the program's project lead. She is ultimately accountable for tracking the program's submission goals and ensuring that applicable sections participate in the monthly blind verification program.

The BQC program consists of mock cases that are prepared and submitted monthly to the participating sections, as well as blind verifications in latent prints and firearms. The monthly submission rates are calculated to target approximately 5% of the technical section's output from the preceding calendar year. Output is defined as the number of requests completed. Admittedly this 5% calculation does not account for the complexity of each case or the number of items that may be included in each case. However, the 5% goal is intended to ensure the BQC program is robust enough to likely expose all of a discipline's analysts to a blind case while not overly taxing resources. Each month the Quality Division submits more than 40 BQCs that mimic real casework into workflows companywide (*see* **Table 1**).

Rates of completion of these BQCs within the program's first five years are shown in **Figure 1**. BQCs are determined to be satisfactory if either the result conforms to the known ground truth or if the result does not conform to the known ground truth but is technically sound and/or the analyst adhered to the discipline's standard operating procedure, or if the result adheres to the requested analysis.

In order to ensure the program's continuous improvement, HFSC staff have an incentive if they accurately identify a BQC. If a staff member correctly identifies a case as being a BQC, they are rewarded with a small gift card. Conversely, if staff misidentify real casework as a BQC, they must pay HFSC's CEO and president, Dr. Peter Stout, $1. The incentive program is designed to ensure that staff reveal any telling information, so the Quality Division can correct and avoid any "red flags" in

Table 1. Monthly case submission rates at which blind quality controls and verifications are submitted

HFSC Technical Discipline	Rate
Toxicology	16
Seized Drugs	15
Forensic biology	4
Firearms	1
Firearms Blind Verification	1
Latent Print Processing	2
Latent Print Comparison	6
Latent Print Comparison Blind Verification	1
Multimedia Digital	1
Multimedia Audio/Video	1

future BQCs. To date, less than 5% of BQCs have been discovered as such, albeit those discoveries may occur for many different reasons.

Challenges — Sample Creation

Facilitating a BQC program of this size has challenges at every step: creating samples, realistic case scenarios, and supplemental case information, mimicking case documentation and packaging, internal logistics and secrecy. The challenges have been varied and, at times, surprising. We have learned that our staff notice even the smallest differences, from handwriting to spelling to the placement of a fingerprint and will do extensive research if any detail appears suspect. By identifying the weaknesses in the program and making staff a part of the project, we have managed to ensure it remains largely "blind" and we have avoided some of the antagonism one might expect when creating a situation where people are constantly being "tested". Overcoming the challenges is not easy and HFSC is still perfecting the system, learning every day how to improve the program.

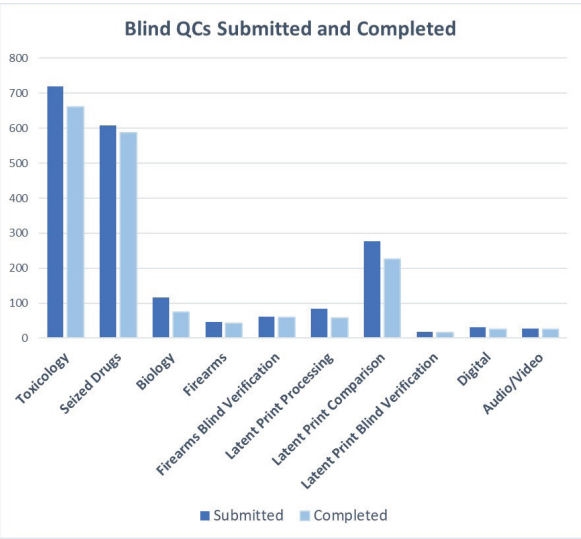

Figure 1. Total number of BQCs and verification both submitted and completed within the first five years of the blind quality control program.

First, mimicking case packaging has proved to be more challenging than originally anticipated. Packaging BQCs in a manner consistent with casework includes ensuring the appropriate packaging type is used — for example, an envelope vs. a bag — but also the specific style, white envelope vs. manila envelope, and size. In addition, the information included on the packaging must mimic that of actual casework. And lastly, the handwriting on the packaging must also mimic that of actual casework. Staff said handwriting that was "too neat" served as a "tell" that a case was in fact a BQC. Special care is now used when writing on BQC submission forms and documentation to ensure it is not "too neat" (*see* **Figure 2**). Writing with a nondominant hand is one technique quality specialists use to prevent handwriting from being easily discovered.

The Quality Division is also challenged by making drawings that are "too nice" (*see* **Figure 3**). Latent lift cards are collected at crime scenes and submitted to HFSC's latent print section. These lift cards include rudimentary drawings that indicate where possible ridge detail may have been collected from the evidence item. While the quality specialist who created the latent lift card did not apply any particular artistic effort when making the evidence item for one particular BQC, the examiner identified it as being abnormal as compared to those typically observed in casework.

Creating latent print section evidence can also be challenging because the Quality Division strives to create evidence that truly mimics casework. The Quality Division attempts to strike a balance between not overly complex and not overly simple when creating BQCs. However,

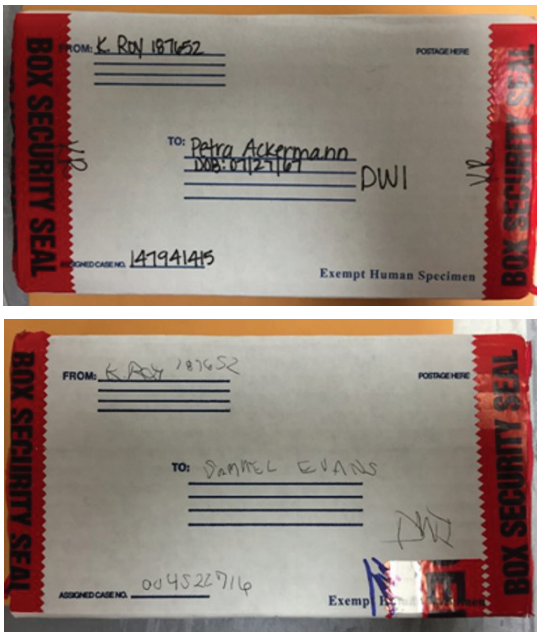

Figure 2. A Toxicology BQC that was discovered because the handwriting was described as "too neat" (upper) and where the non-dominant hand was used for all writing (lower).

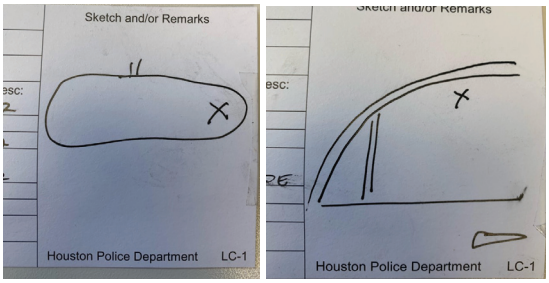

Figure 3. A Latent Print BQC that was discovered because the drawings of the rearview mirror (left) and driver-side window (right) were described as too nice.

despite various attempts made by the Quality Division, latent print examiners have still been able to successfully identify BQCs. One particular latent lift card was discovered because a portion of the card appeared "too deliberate" (*see* **Figure 4**).

When interviewed, the latent print examiner who identified this BQC stated the latent prints on the card didn't look "natural" and appeared to have been deliberately placed. The placement of a possible fingerprint in the middle of what appeared to be a palm print raised suspicion. In addition, the latent prints weren't oriented in a manner that was consistent with the natural handling of this item, a latent lift described as being from a metal shutter.

Challenge — Report of Non-expected Result

The BQC program has also experienced instances when analysts reported non-expected results. In these instances, the Quality Division investigates in an attempt to determine the potential source of error.

Forensic Toxicology BQC. A toxicology report issued on February 26, 2020, for a DWI collection kit BQC indicated the ethanol concentration detected in item 001-01 (one blood tube) was 0.246±0.023 g/100 mL. The expected result for this BQC submission was 0.0 g/100 mL (negative). The Quality Division launched an investigation into the cause of the discrepancy. The investigation pursued three possibilities for this error: a Quality Division error during submission, a toxicology section error during analysis, or a manufacturing error involving the production or labeling process.

Item 001-01 from the BQC was retested on March 13, 2020, and yielded the same results as the first time it was reported. The Quality Division reviewed the photographs taken during HFSC's DWI collection kit accessioning process and confirmed the blood tubes for the BQC had the appropriate laboratory labels that were affixed during accessioning. The Quality Division also maintains records of the assembly of BQCs and as part of this documentation the original manufacturer labels are transferred and retained. The investigation of this portion of the process revealed consistent Quality Division paperwork, no apparent discrepancies and all the expected manufacturer labels.

A further review of the Quality Division's BQC records showed that on the date of preparation of the BQC, the division prepared and submitted three other toxicology DWI collection kit BQCs. The Quality Division reviewed the records from the three other toxicology BQCs and found no concerns.

In Houston, a toxicology kit typically contains three tubes of blood from one individual. HFSC's toxicology section routinely tests one of those blood tubes to determine its blood alcohol concentration. Therefore, the DWI collection kit BQC had two as yet untested blood tubes (items 001-02 and 001-03). The toxicology section tested items 001-02 and 001-03. Both items 001-02 and 001-03 yielded the expected negative result, meaning only one blood tube from the BQC DWI collection kit had unexpected results.

Figure 4. A Latent Print BQC that was discovered because the analyst identified the indicated portion as being too deliberate.

In addition, all three blood tubes from the other three toxicology DWI collection kit BQCs prepared on the same day were tested and all yielded the expected results. Therefore, there was no evidence that any error had occurred during the submission process.

The Quality Division interviewed the toxicology analyst who performed the original testing on item 001-01. During the interview the analyst discussed the quality control measures that the toxicology section has in place to prevent a sample switch from occurring. In addition to sampling each tube twice during alcohol analysis, the toxicology section performs the sampling order in reverse the second time. Agreement between the duplicate results is required, and a case will be reanalyzed if the results do not meet this criterion. In addition, the analyst also described the specific engineering controls that she uses when performing blood alcohol analysis, including placing each blood tube upside down in the sample rocker as she completes her first sampling. There is also a sequence verification step that requires a second, independent analyst to verify the location of each sample on the instrument autosampler prior to starting the instrument.

Five other samples in the same toxicology batch as item 001-01 yielded negative ethanol results. Altogether the batch had 30 evidence blood tubes. To eliminate the potential that a laboratory labeling error may have resulted in a sample switch, the Quality Division reviewed the photographs taken during the accessioning process for all five of these cases. All the blood tubes for each of the five cases had the appropriate labels from the creation, submission, and accessioning processes. Two of the negative samples in the batch were sequentially positioned as the first two evidence samples in the batch, whereas BQC item 001-01 was the last sample in the batch. In addition, the first two tubes were both from a toxicology drug-facilitated sexual assault kit. These tubes have a different physical appearance than those used in the DWI collection kit tubes. Both the positioning of the tubes and the physical appearance of the tubes minimize the likelihood of a sample switch with either of these samples.

The other three negative samples in this batch were from DWI collection kits. Because these samples yielded negative results, they were then submitted for presumptive drug screening analysis as is the standard operating procedure in HFSC's toxicology section. The drug screening analysis for one of the cases resulted in a positive drug screening result for a drug not contained in the Quality Division blind program, eliminating the possibility that this case had been switched in sampling.

Finally, the Quality Division contacted the manufacturer of the toxicology BQCs blood tubes to gain insight into their manufacturing and labeling processes. The manufacturer's process includes adding the appropriate concentration of blood into the specific number of already labeled tubes. Other quality checks ensure that blood tubes with different concentrations are not swapped and the production record for this specific batch indicated the production of the negative concentration was completed approximately 2 h before production began on the tube with the 0.24 g/100 mL concentration. The records also indicated that a tube label verification step occurred.

Once it became clear that the blood product is added to prelabeled tubes, the HFSC Quality Division suspected the labeling process could be the source of the error. The labeling process included hand-typing the batch information, concentration, and date in Microsoft Word and using a label template to simultaneously create multiple label pages. Each page contains 30 labels and the labels for each concentration are created separately. The vendor laboratory has controls and policies to ensure all tubes in a batch are labeled with the generated labels for that concentration. This assumes the labels themselves are correct. Given the manual nature of the label generation, the HFSC Quality Division questioned whether the label sheets themselves were accurate.

The vendor laboratory had retained the electronic label files used to fulfill this order. Upon review of the electronic label files, one label stuck out: that label read "BAC 12198-41-2 Negative August 13, 2019" and was included on a sheet with 29 other labels that read "BAC 12198-41-4 0.24% August 13, 2019". Thus, one 0.24 g/100 mL blood tube was labeled as "BAC 12198-41-2 Negative August 13, 2019". This was the suspect tube that the Quality Division had incorporated into the submitted blind QC with an expected result of "negative" when in fact the tube contained 0.24% BAC blood. The HFSC laboratory result correctly identified the alcohol concentration of the blood contained in the BQC item 001-01 blood tube. It was the original label affixed by the manufacturer to the tube that was in fact wrong.

Upon discovery, the vendor laboratory committed to treating this label discrepancy as a nonconformance and has implemented a process improvement of its own in response. The manufacturer revised its standard operating procedure to require staff to create a new label file for each concentration type, thus preventing the template from being copied and pasted between concentrations.

Forensic Biology BQC. A non-expected result also occurred in a forensic biology BQC. The Quality Division created the BQC by having a female staff member rub a swab along the back of her neck with the intention of depositing her skin cells on to the swab. A quality specialist then packaged the swab accordingly and submitted it to the forensic biology section as a "steering wheel swab" in an auto theft case. Although the Quality Division expected a single-source female DNA profile to result from the testing, the DNA analyst in fact identified a mixture. The mixture consisted of at least two contributors, at least one of whom was male. The major contributor to the mixture was consistent with the female staff member who created the swab. In accordance with the forensic biology SOP, the DNA analyst searched HFSC's elimination database for the DNA of the major contributor. HFSC's elimination database is an in-house database that contains DNA profiles for all HFSC staff as well as any visitors to the forensic biology laboratory. As expected, the DNA analyst found the major contributor's profile to be consistent with one of a known staff member and flagged the case for review by the Quality Division, which ultimately confirmed it to be a BQC. But because the Quality Division expected the sample to contain only the female contributor's DNA, it began researching the potential source of the foreign DNA. Because the staff member created the BQC by swabbing the back of her neck, the Quality Division considered her to be an assumed contributor to the DNA mixture and was able to use her profile to better isolate the DNA from

the foreign contributor. The DNA profile of the foreign contributor was also searched in the in-house elimination database, but no consistent match was identified there.

The Quality Division then interviewed the female staff member and confirmed she resides solely with her husband. A request was then made for her husband's DNA profile, so it could be compared to the DNA profile of the foreign contributor in the BQC. Thankfully, her husband willingly provided a DNA reference sample by swabbing the inside of his mouth. His DNA profile was then generated and confirmed to be consistent with that of the foreign contributor. Because the staff member had created the BQC approximately one year prior to discovery, there was no expectation she would be able to recall specific details of that day and that information was not documented. For example, had the staff member worn her hair up that day, exposing the back of her neck? Had she worn a scarf, jacket, or blazer that could have had her husband's DNA on it since they reside together and presumably launder their clothes together? Had she showered that morning or the night before? What was her morning routine that day? These are questions that we will never know the answers to in this case but do provide insight into the BQC program's sample creation practices and certainly suggest that such information may be useful to document when creating future forensic biology BQCs.

Seized Drugs BQC. Another non-expected result came back from a seized-drugs BQC that contained a PCP-laced cigarette. This BQC was submitted through the section's normal workflow and the analyst successfully detected and reported the presence of PCP. To conserve resources, the same PCP cigarette was then submitted a second time into the section's workflow and another analyst also successfully detected and reported the presence of PCP. Almost a year after the first submission, the Quality Division submitted that same cigarette for a third time into the section's workflow. This time, however, the analyst reported no controlled substances had been detected. The Quality Division, knowing PCP had been added to the cigarette and being aware of the results of the two previous submissions, launched an investigation.

With the help of a seized-drugs supervisor, the BQC sample was reanalyzed. The reanalysis again found no controlled substances in the sample. The Quality Division learned that the sample was not homogenous, meaning the cigarette was not evenly laced with PCP. So, each time an analyst sampled the cigarette for analysis, they removed some of the PCP. By the third time, there wasn't enough PCP for the analysis to detect. Based on these results, the Quality Division made some process changes and now only submits PCP cigarettes within six months of creation and only submits each cigarette twice.

As demonstrated from the examples above, the BQC program has identified areas for improvements at all stages of a process, including in the first step: creation of the samples themselves.

Transcript Review Program

Forensic science does not end when the laboratory work is completed and a report is issued. Ultimately, analysts must also be able to present the work they did and their findings, in layman's terms, in a courtroom, most specifically to a jury. In recent years, expert testimony by forensic scientists has come under heightened scrutiny. In some cases, the science itself, such as bitemark evidence, has been questionable to begin with and the court testimony only served to exacerbate matters. However, more often, the science is not the problem but whether the testimony itself has remained within the limitations of the expert's expertise and of the science itself. Prosecutors, defense counsel, and even the judge have each played a role at different times in misleading a jury by forcing an analyst to respond to a question that might take the science or the results out of bounds. Other times, the analysts themselves are simply not trained well enough to deal with the pressures of testimony. Aware of the risks involved with testimony, the issues that have increasingly been brought to light, and the microscope under which this final part of the forensic process has been placed, HFSC moved to implement an additional layer of testimony monitoring into its quality management system.

In 2018, HFSC launched a unique quality initiative called the transcript review program. The program was originally designed to bolster an accreditation requirement that all analysts who testify in court be monitored by a technical expert at least once a year. But in the two years since its inception, the transcript review project has proved even more valuable than initially anticipated and has helped the Quality Division identify numerous opportunities for improvement.

Some statistics on the number of transcripts reviewed per discipline are shown in **Figure 5.**

To obtain the transcripts for review, the Quality Division makes quarterly requests for transcripts. Once received, a transcript is first reviewed by the testifying analyst. The division then "blinds" all identifying information from the transcript to minimize potential bias in the review process. Once "blinded", the transcript is provided to a three-person panel for review. The panel is made up of a staff member with technical expertise in the specific discipline of testimony, a Quality Division representative, and a nontechnical staff member that serves as a layperson. Each panel member reads and evaluates the transcript independently; then the group meets to discuss

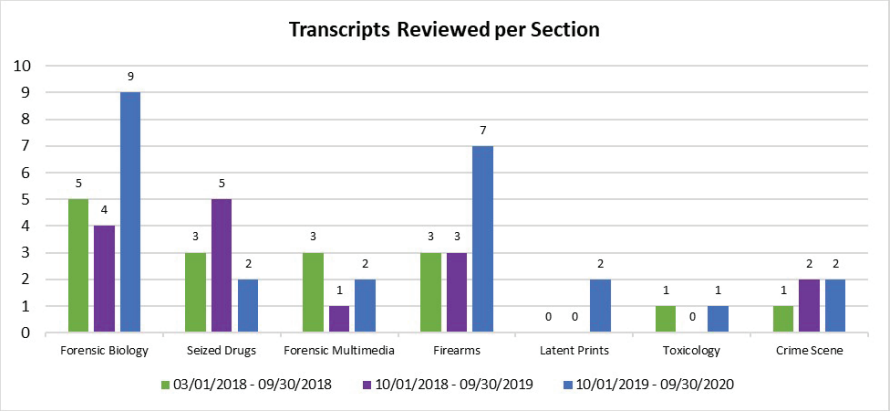

Figure 5. The number of transcripts reviewed per technical section since the inception of the transcript review project in 2018.

the transcript and to produce a comprehensive evaluation. That feedback is then provided to the analyst with the goal of identifying well-articulated responses as well as any potential opportunities for improvement.

Some of the feedback is individual to the testifying analyst. But the Quality Division has also spotted trends across testimonies that allowed for broader staffwide improvement. For example, the Quality Division designed and facilitated a training that focused on the routine qualifying questions asked during testimony. HFSC required all technical staff to attend the training and subsequently uploaded reference materials presented during the training into HFSC's online record management system to ensure the resources are continuously available. Sections will also be incorporating some of the redacted transcripts into their own training programs, allowing trainees to review them in preparation for mock trials and real court appearances. The transcripts will also be available for all technical staff to review.

The project has also helped identify strong testifiers and strong testimonies. These testifiers can be mentors for trainees, help facilitate more effective mock trials, and provide valuable feedback to less-experienced analysts. After a panel identified particularly strong testimony, the Quality Division provided an excerpt of the transcript to all technical staff and required them to document their reviews. By sharing information in this manner, staff are exposed to responses they can potentially incorporate into their own testimony.

The project also uncovered one testimony that was more problematic. The review of that transcript found a former staff member had testified outside the scope of his expertise. During testimony, a crime scene investigator made numerous statements regarding the source of footwear impression evidence and used terminology such as "matched" in his testimony.

HFSC disclosed the incident to the Texas Forensic Science Commission (TFSC), the state's nine-member forensic oversight board that is also one of HFSC's accrediting bodies. The commission, whose members are appointed by the governor, also requires licensing for analysts from disciplines that must be accredited under state law, including forensic biology/DNA, firearms, seized drugs, toxicology, and trace. HFSC is required to disclose such incidents to the TFSC. But HFSC also used the incident to highlight the issue to staff by providing them with excerpts from the testimony and discussing the limitations of testimony. The Quality Division also created a video training featuring staff interviews with representatives from each HFSC technical discipline. During the recorded interviews, staff discussed their testimony experiences, preparation practices, and personal experiences with accidently misstating information during testimony and how they corrected the record. The purpose of the training was for all staff to benefit from the experiences discussed and promote an environment of information sharing. In its final decision, the TFSC, which has the authority to investigate or censure an accredited crime laboratory or an individual analyst, voted to take no further action, meaning HFSC had taken appropriate action when it discovered the incident. The commission also praised HFSC's program, noting "the laboratory discovered the issue as a result of a proactive and commendable transcript review program".

Concluding Remarks

Although both initiatives have been successful in enriching HFSC's quality management system, the Quality Division is always striving for excellence and is therefore continuously looking for ways to improve both the BQC program and the transcript review project.

Although the BQC program recently celebrated its five-year anniversary, it is still essentially in its infancy. The Quality Division is now able to routinely meet all of its monthly submission goals with only a minimal number of blinds detected. Building on this solid foundation, the program is now ready to identify and take steps to expand further. Over the next five years, the program will work to incorporate sexual assault kits into the forensic biology BQC program. Texas recently implemented a sexual assault kit tracking program, and HFSC's BQC program will not

only provide useful information about workflow but may also benefit the tracking program by looking at it from another vantage point. The introduction of sexual assault kits into the BQC program also serves as a springboard to including DNA mixtures in BQC samples. Until now, forensic biology BQCs have focused on single-source DNA profiles, but insight into the section's mixture interpretation workflow could add tremendous value. The section also began using the probabilistic genotyping software, STRmix™, in casework at the end of 2019. The BQC program could also provide insight into how these recently incorporated procedures are operating.

There are costs associated with the BQC program, the overwhelming majority of which is attributed to purchasing toxicology BQCs. BQCs for other disciplines are created by the Quality Division using purchased household items at a minimal cost (*see* **Table 2**). When possible, the division acquires at no cost Houston Police Department evidence slated for destruction.

Creating toxicology BQCs in-house could result in significant cost savings. Within the next five years the Quality Division will be researching the purchase of whole blood product or the possibility of securing donated blood. The blood would have to be spiked with ethanol and/or drugs and prepared in bulk. Once created, a quality control check would need to be performed to ensure that appropriate concentrations were achieved; however, having an option of creating the toxicology BQCs in-house could create a significant cost savings for HFSC.

Table 2. Approximate costs[a] of blind quality control (BQC) samples and externally purchased proficiency tests (PTs) samples per year

Forensic disciplines	Cost of supplies for blind QC samples					Cost of external PTs[a]				
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
Toxicology	$16,000	$122	$16,716	$28,901	$30,056	$1,950	$2,010	$1,720	$1,765	$1,075
Firearms	$0	$0	$0	$0	$0	$2,790	$2,580	$2,300	$2,245	$900
Seized drugs	$0	$0	$5,300	$165	$0	$3,240	$2,960	$3,230	$3,060	$2,880
Forensic biology	n/a	$0	$1,840	$0	n/a	$7,732	$8,633	$8,608	$8,262	$9,450
Latent prints	n/a	$0	$0	$20	n/a	$5,340	$6,520	$6,130	$6,060	$2,110
Digital forensics	n/a	n/a	$0	$378	$118	$1,898	$2,490	$2,786	$2,490	$2,525
Audio/video	n/a	n/a	n/a	$221	$90	$1,750	$3,150	$4,550	$4,125	$3,000
Miscellaneous	n/a	n/a	$1,210	$334	n/a	n/a	n/a	n/a	n/a	n/a

[a] Data for years 2015–2018 were taken from Ref. [3].
[b] An external PT was typically purchased for each analyst during these years, with the exception of forensic biology in which analysts are required to participate in two external PTs.

The transcript review project will continue to provide opportunities for improvement as more testimony is reviewed. There is currently no hard cost affiliated with the project as requests for transcripts are reserved for cases that are in the appeals process. While these are provided to HFSC at no cost, the number of potential transcripts that can be reviewed is limited. The project's goal is to review at least one transcript from each analyst who testifies in a given year. Due to the known variation in transcript costs (depending largely on the size of the transcript) the estimated budget for purchasing such documents could be between $100 and $1,000 per transcript. As referenced in the above provided data, in 2019 HFSC had 51 analysts testify. Requesting one transcript for each analyst could potentially cost HFSC from $5,000 to $50,000. That budget could be supplemented by transcripts available from the appeals process, but the number would be minimal inasmuch as only 12 transcripts were reviewed in 2019.

Lastly, both the BQC program and the transcript review project could greatly benefit from the collaboration of one or more other laboratories. There are several ways in which a collaboration could be beneficial for all participants: an exchange of BQCs, reanalysis of HFSC BQCs, participation in an HFSC transcript evaluation, or an exchange of transcripts. As HFSC moves to expand and improve its BQC program, it intends to collaborate with other forensic laboratories so that we can learn lessons together and make broader, communitywide improvements to the science.

References

1. Liptak A: Worst crime lab in the country — Or is Houston typical; *The New York Times* March 11, 2003.
2. [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).
3. Hundl C, Neuman M, Rairden A, Rearden P, Stout P: Implementation of a blind quality control program in a forensic laboratory; *J Forensic Sci* 65:815; 2020.

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CRC Press: Boca Raton, FL, US; 2020

Detecting Malingering and Deception, Forensic Distortion Analysis (FDA-5), 3rd ed

H. V. Hall, J. Poirier
CRC Press: Boca Raton, FL, US; 2020

Forensic Gait Analysis: Principles and Practice

I. Birch, M. Nirenberg, W. Vernon, M. Birch
CRC Press: Boca Raton, FL, US; 2020

Forensic Handwriting Identification: Fundamental Concepts and Principles, 2nd ed

R. Morris
Academic Press/Elsevier: Waltham, MA, US; 2020

Forensic Pathology Case Studies

E. Guareschi
Academic Press/Elsevier: Waltham, MA, US; 2020

Forensic Practitioner's Guide to the Interpretation of Complex DNA Profiles

P. Gill, Ø. Bleka, O. Hansson, C. Benschop, H. Haned
Academic Press/Elsevier: Waltham, MA, US; 2020

Forensic Science Handbook, Vol I, 3rd ed
R. Saferstein, A. B. Hall, Eds

CRC Press: Boca Raton, FL, US; 2020

Handbook of Trace Evidence Analysis

V. J. Desiderio, C. E. Taylor, N. N. Daéid, Eds
Wiley-Blackwell: Somerset, NJ, US; 2020

Interpreting Bone Lesions and Pathology for Forensic Practice

L. Biehler-Gomez, C. Cattane
Academic Press/Elsevier: Waltham, MA, US; 2020

Long 'on' the Tooth: Dental Evidence of Diet

C. Schmidt
Academic Press/Elsevier: Waltham, MA, US; 2020

Public Speaking for Criminal Justice Professionals: A Manner of Speaking

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

Sex Estimation of the Human Skeleton: History, Methods, and Emerging Techniques

A. Klales, Ed
Academic Press/Elsevier: Waltham, MA, US; 2020

Shooting Incident Reconstruction, 3rd ed

M. Haag, L. Haag
Academic Press/Elsevier: Waltham, MA, US; 2020

Statistics and Probability in Forensic Anthropology

Z. Obertová, A. Stewart, C. Cattaneo, Eds
Academic Press/Elsevier: Waltham, MA, US; 2020

Strategic Leadership in Digital Evidence: What Executives Need to Know

P. Reedy
Academic Press/Elsevier: Waltham, MA, US; 2020

Veterinary Forensic Medicine and Forensic Sciences

J. H. Byrd, P. Norris, N. Bradley-Siemens, Eds
CRC Press: Boca Raton, FL, US; 2020

Book Reviews

Forensic Science: An Introduction to Scientific and Investigative Techniques, 5th ed

Suzanne Bell

CRC Press: Boca Raton, FL, US; 2019

Reviewed by

Elizabeth Gardner
Department of Criminal Justice
University of Alabama at Birmingham
Birmingham, Alabama
United States of America
+1-205-934-0668; eagard@uab.edu

The fifth edition of *Forensic Science: An Introduction to Scientific and Investigative Techniques*, by Suzanne Bell[a], is an overview of forensic science intended for high school and lower-level college courses. It has three added features:

- The first is the crime scene scenario[b] that is woven into most of the subsequent chapters to demonstrate how the seemingly disparate forensic science disciplines are interconnected. The case is either explicitly referenced or it is included in the advanced questions and exercises.
- The advanced questions and exercises are the second addition, designed to be utilized as an added honors component, extra credit assignments, or to introduce group activities into the course.
- A third feature exposes the "Myths of Forensic Science", debunking common misconceptions about time-of-death determinations, handwriting analysis to interpret personality, and the infallibility of DNA.

The textbook is designed to be a one-semester overview of forensic science with core material organized in Chapters 1–6 and 9–15. The remaining chapters can be used to customize the course according to the instructor's needs or interest. Chapters 16, 18, 20, and 21 are standalone and can be used to round out the course. Chapters 7, 8, 17, and 19 can be used to introduce a more advanced level of instruction.

Each chapter concludes with a section of review material including key terms and concepts, review questions, and advanced questions and exercises. In addition, each chapter is liberally interspersed with photographs and images that illustrate the concepts being introduced in the chapter. The images are from authentic sources, not the stock images reproduced in almost every textbook. They are a real strength of the book and attest to the resources expended in the creation of this edition.

The goal of the author is to encourage high school and undergraduate students to develop an interest in the science that forms the backbone of the forensic disciplines. This is accomplished by including numerous detailed examples taken from real cases and a liberal serving of photographs and images that clearly illustrate the science presented in the text.

Core Chapters

The core Chapters 1–6 cover the role of forensic science in the judicial system, evidence, crime scene investigation, bloodstain patterns, medicolegal death investigation, and postmortem toxicology. Chapter 1 (Justice and Science) sets the context of forensic science in the courts and provides a short history of the field. The final sections cover the court system and ethics. Chapter 2 (Evidence Origins, Types, and Admissibility) builds on Chapter 1 by defining evidence, the Federal Rules of Evidence, and the *Daubert* trilogy. The crime scene scenario is introduced, appropriately, in Chapter 3 (Crime Scene Investigation). This chapter starts with defining the different types of crimes scenes and the processes for investigating them: documentation, measurement, imaging, and searching. This chapter also covers the basics of evidence collection, chain of custody, packaging, and preservation. The final section goes through the crime scene processing using the crime scene scenario presented at the beginning of the chapter. A large number of photographs illustrates what might be found at a crime scene such as that provided in the scenario.

Chapters 4–6 begin to focus in individual areas in forensic science. Chapter 4 (Bloodstain Patterns) starts with the physical properties of blood and how they affect the interpretation of blood found at the crime scene. Again, the photographs and images are a strength in the presentation of this material. Chapters 5 and 6 are interrelated, focusing on Medicolegal Death Investigation and Postmortem Toxicology, respectively. Medicolegal death investigation covers the medical examiner/coroner systems and the manner and cause of death. A short description of an autopsy is followed by a discussion of the types of trauma, sharp force, blunt force, gunshot, and asphyxia. Postmortem toxicology focuses mainly on the dose response relationship and ADME (absorption, distribution, metabolism, and excretion). The types of samples and the analysis are

[a]Suzanne Bell has worked in the field with the New Mexico State Police and is a retired chair of the Department of Forensic and Investigative Sciences at West Virginia University. She served on the gunshot residue committee of the National Institute of Standards and Technology's (NIST) Organization of Scientific Area Committees (OSAC). Dr. Bell is a past member of the National Commission on Forensic Science (NCFS) and the Forensic Science Education Programs Accreditation Committee (FEPC). She is the author of 14 books and textbooks on forensic science.

[b]A crime scene is introduced in Chapter 3. A woman is found dead in her home. The neighbors heard shouting the night before, but that was nothing that hadn't happened before. The husband was found in a motel room in a neighboring city.

touched on lightly. Toxicology is revisited in Chapter 11 Drugs and Poisons, where the focus is on toxins.

The second set of core chapters, 9–15, starts with forensic biology then proceeds to forensic chemistry, with drugs and poisons, arson and fire investigation, and explosives and improvised explosive devices. The final core chapters return to criminalistics, with the topics of fingerprints, firearms, and tool marks. Chapter 9 (Biological Evidence) focuses on serology, stressing the importance of being able to find the biological evidence that will make DNA analysis possible. Chapter 10 (DNA Typing) provides the necessary background on DNA before delving into DNA typing. It also touches lightly on the Combined DNA Index System (CODIS) and mitochondrial DNA. The chapter ends with a nice discussion of the current issues in DNA typing.

Chapter 11 (Drugs and Poisons) is the first chapter of four core chapters on forensic drug chemistry. The chapter introduces the concepts of intoxication, drug classification, and the Controlled Substances Act. Representative drugs from the opiate, stimulant, cannabinoid, and novel psychoactive substances classes are discussed, along with a clandestine lab. Presumptive and confirmatory testing of powders and plant materials is covered briefly, along with toxicology testing for alcohol and poisons (cyanide and carbon monoxide). Driving under the influence of drugs (DUID) was not covered and seems a missed opportunity. Chapter 12 (Arson and Fire Investigation) starts with the chemistry of combustion and the components of fire: fuel, heat, oxygen, and chemical chain reactions. The two aspects of fire investigation, point of origin and presence of accelerants lead into the laboratory analysis of accelerants. The chapter finishes with an in-depth discussion of the 2003 fire in the Station night club in Rhode Island. The review of arson leads into Chapter 13 (Explosives and Improvised Explosive Devices). The majority of the chapter is on the physics of explosions. The application of forensic science focuses less on the chemical analysis and more on the physical evidence found with the explosive device. For example, how fingerprints and DNA can often be recovered from pieces of the bomb or its packaging.

The last two core chapters cover pattern evidence, fingerprints, and firearms and tool marks. Chapter 14 (Fingerprints) covers the basics of fingerprint classification, along with physical and chemical methods of development. This chapter continues the crime scene scenario with multiple sites from which prints could be recovered and gives examples of the types of prints that might be found at such a crime scene. Chapter 15 (Firearms and Tool Marks) contains a review of firearms and ammunition and then provides a brief description of the types of analyses performed by tool mark examiners. Bullet and cartridge comparisons, distance determination, serial number restoration, and tool marks are covered as well as the emerging technologies for image analysis for a statistical analysis of cartridge comparisons.

Stand-Alone and More Advanced Chapters

The remaining eight chapters were designed to be included as part of the course in total or selected to meet the needs of the course. Chapters 7 (Forensic Anthropology) and 8 (Forensic Entomology) follow logically from Chapter 5 (Medicolegal Investigation of Death) and Chapter 6 (Postmortem Toxicology). Grouped together, they could form a module on forensic pathology. Forensic Anthropology focuses on the information that can be gleaned when only the bones remain. A section on recovering the remains is followed by sections on building a biological profile and identification of the remains. The chapter ends with a discussion on interpreting trauma to the bones as an aid in the determination of the cause and manner of death. The focus of Chapter 8 is on the information that insects can provide on not only the post mortem interval, but also includes more recent developments in extracting drugs and even DNA from the insects that have fed on the corpse.

The core chapters on "Fingerprints" and "Firearms and Tool Marks" could be combined with Chapter 16 (Tread Impressions), Chapter 17 (Trace Evidence and Microscopy), and Chapter 18 (Questioned Documents) for a criminalistics course. Tread impressions is a relatively short chapter that includes both footwear and tire impressions, methods of collection, and examination of both class and individual characteristics. Chapter 17 describes the different types of microscopy used in the analysis of trace evidence and provides a short review of the different types of trace, including glass, fiber, paint and soil. Finally, Chapter 18 includes both classic methods for comparing handwriting samples and touches on computer technology that can provide quantitative analysis of handwriting features.

Chapter 19 (Forensic Engineering) could be combined with the chapters on "Arson and Fire Examination" and "Explosives and Improvised Explosive Devices" could be combined to form a module on physics, in the same vein as forensic chemistry and forensic biology. The final two chapters include topics that many students would not expect to be included in forensic science: Chapter 20 (Computer Forensics) and Chapter 21 (Behavioral Science).

E-Book and Instructor Resources

In addition to the hardcopy text, an accompanying e-book with audio is available to the student via a code on the inside front cover. Instructor resources include PowerPoint® lecture slides for every chapter, an instructor's manual with questions and answers, chapters from previous editions, two extra case studies on (a) firearms and arson and (b) entomological evidence, and animal scavenging.

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

Randall C. Baselt
Biomedical Publications: Seal Beach, CA, US; 2019

Reviewed by

Yi Ju Yao
Analytical Toxicology Division
Health Sciences Authority
Singapore
+65 6213 0743; yao_yi_ju@hsa.gov.sg

The first *Disposition of Toxic Drugs and Chemicals in Man* that our library had was the 2nd edition, published in 1982, and over the years, we acquired a few more editions (6th, 8th, 9th, 10th, and 11th) as it has become one of the most important resources that we rely on for a quick check on drugs/chemicals. Although information is plentiful on the worldwide web, we may not have access to all relevant sources, and most would not have the time to search thoroughly enough. Borrowing from the words of R.B.H. Gradwohl, which were aptly quoted in the preface of the 12th edition, this work by Dr. Baselt provides a shortcut to "the information that is so widely scattered throughout the journal literature of the past three or four years, and boiled it down into a readily digested form".

The 12th edition continued the structure of previous editions, starting each monograph with the data on elimination half-life ($t_{½}$), volume of distribution (Vd), plasma protein binding (Fb), acid dissociation constant (pKa), blood:plasma ratio, CAS number, molecular formula and mass, chemical structure. This is followed by a summary of pertinent information (typically 1–3 pages) regarding the sources, usage and doses, blood/plasma/serum concentrations under normal doses and routes of administration, metabolism and excretion, toxic responses and the corresponding blood levels, blood and tissue levels in fatal cases, postmortem redistribution, bioanalytical approaches, and in vitro stability. Each monograph is typically one to three pages long, and longer for some such as the monograph on synthetic cannabinoids as a class as these evolving psychoactive substances have similar pharmacology. For those who want to delve into the details, references are also provided for each drug/chemical.

Prior to the monographs, there is a prologue titled "Guidelines for the Interpretation of Analytical Toxicology Results", written by Dr. Robert Flanagan and Dr. Robin Whelpton. This section first appeared in the 9th edition and has also been updated through the editions. It may be easily missed by those who dive straight into the monographs, but the prologue serves as an important reminder to the toxicologists, pathologists, and clinicians of the context and factors affecting the interpretation of toxicology results.

From our first "Baselt" 2nd edition, the number of drugs/substances included had expanded from 305 to more than 2,000 in the 12th edition. Dr. Baselt and his team had made a concerted effort to update the book every few years (every 3 years since the 8th edition) and more than 200 new drugs/chemicals were typically added with each new edition. The current listings of the 2,000-plus drugs/chemicals include pharmaceuticals, antidotes, elements, agents used in medical procedures (e.g., imaging agents), pesticides, environmental and industrial toxicants, dietary sweeteners and supplements (including vitamins and amino acids), plant and animal toxins, to substances of abuse (including anabolic steroids, novel psychoactive substances), and many other commonly encountered substances in the field of toxicology. The detail listing of the drugs/chemicals and their CAS numbers can be found on the publisher's website (*www.biomedicalpublications.com*).

In this 12th edition, where over 280 new entries were added, I was pleasantly surprised to see the addition of "older" drugs/chemicals such as nimetazepam, aristolochic acid, and cerberin, which we had encountered in our caseworks. Nimetazepam is a benzodiazepine originally manufactured by Sumitomo, a Japan Pharma company, as a therapeutic agent for insomnia. It was abused in our region (Southeast Asia) since close to two decades ago, with street names such as "Erimin 5".

Aristolochic acid is a nephrotoxic component in plants of the Aristolochia genus that are used in some traditional Chinese medicine. Confusion in the common Chinese names of the herbs often leads to accidental substitution of the relatively nontoxic "Chuan Mu Tong" *(Clematis armandii*) with the toxic "Guan Mu Tong" (*Aristolochia manshuriensis*), causing nephrotoxicity. Cerberin (2'-acetylneriifolin) is a toxic cardiac glycoside found in the kernel of the fruits of *Cerbera odollam* (pong pong tree, suicide tree) and *C. manghas* (sea mango), both of which are native to Southern Asia and some Pacific islands. Accidental or intentional ingestion of the seeds was reported to be responsible for over 500 deaths in the years from 1989 to 1999 in Kerala, India. There have also been a few reports of pong pong fruit poisoning in the West in recent years too, making its appearance in this latest edition a timely inclusion.

The 12th edition of *Disposition of Toxic Drugs and Chemicals in Man* is concise, convenient to use, and up to date. It is definitely an invaluable resource to have in the libraries of toxicology laboratories and those working in related fields. The author had previously stated (in the preface of the 10th edition) that an electronic version of this book is not in the pipeline. I am still hopeful that with advances in technology to protect copyright and innovative ways of affordable subscription, a "Baselt" e-book can be made available in the next edition. The accessibility of such an important reference in the electronic form would be especially useful should remote working become the new norm as a result of the corona pandemic.

TEITELBAUM'S COLUMN ON FORENSIC SCIENCE — HISTORICAL PERSPECTIVE —

Numbering of different ridge points [*Finger Print Magazine*; 1924; public domain].

Fingerprint by Telegraph

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

The use of fingerprints by law enforcement agencies began to supplant Alphonse Bertillon's anthropometric measuring system in the late 1890s and early 1900s. Both systems required the use of extensive filing systems that employed hundreds of thousands of individual filing cards. For instance, in the 1920s, the New York Police Department had approximately 400,000 fingerprint cards in its files, the US Penitentiary at Leavenworth had around 300,000, and many European police bureaus had similar numbers [1].

Because of the physical limitations of these systems, a common problem for law enforcement agencies was the criminal who escaped detection by crossing state lines, or by crossing into a bordering country. Even if a fingerprint sample could be mailed or transported to another police bureau, precious time would be lost, and it might prove difficult to match because there were so many different fingerprint classification systems in use at that time.

Different 10-Print Classification Systems and the Single-Print System

A survey conducted in the early 20th century revealed that the Klatt and the Roscher fingerprint systems were in use in Germany, the Jorgensen system in Denmark, the Gasti system in Italy, the Vucetich system in South America and Spain, a combination of the Vucetich and Henry systems in Paris, the Windt-Kodicek system in Vienna, the Daae system in Norway, the Pottecher system in French Indochina, the Henry system in the US and England [2], to name just a few.

And it wasn't just the different classification systems that made it difficult to move from one bureau to another, but the fact that each police bureau gathered fingerprints that were specific to their particular jurisdiction or territory. So even if a police bureau wanted to check their files for a suspect from another jurisdiction, state, or country, it was unlikely that they would have the fingerprints in their file system.

Yet another element of many fingerprint systems that complicated the ability to search a different system was the 10-print system versus the single-fingerprint system. The 10-print system incorporated the patterns of all 10 fingers in order to complete an identification, but this made it difficult, if not impossible, to make an identification based solely on a single fingerprint found at a crime scene. A variety of single-fingerprint systems were soon developed, but the lack of uniformity from one police department to another made coordination between bureaus challenging.

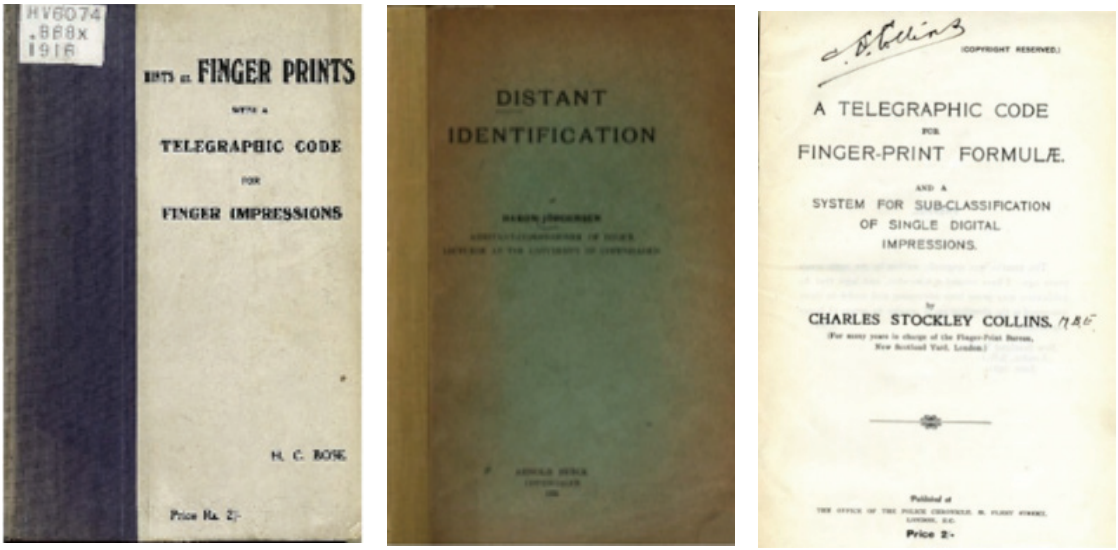
Transmitting Fingerprint Details Through Fingerprint-Coding Systems

Nevertheless, a number of individuals began to develop systems that would theoretically enable law enforcement organizations to transmit fingerprint details using the wireless technology systems that were available in the early 1900s. Morse code, radio, and early telephone systems were seen as potentially viable ways in which information about a suspect could quickly be communicated not only to another state or bordering country, but even across oceans.

The first published wireless system was a book titled, *Hints on Finger-prints with a Telegraphic Code for Finger Impressions* (**Figure 1A**), written in 1916 by Hem Chandra Bose, a fingerprint expert working in India's Calcutta Anthropometric Bureau. The next published system was *Distant Identification* (**Figure 1B**), a book published in 1922 by Hakon Jorgensen, a fingerprint expert in Denmark (although he printed a textbook on his method for use at the Danish Police School in 1916). And the third publication was titled, *A Telegraphic Code for Finger-print Formulae* (**Figure 1C**), in 1922 by Charles Stockley Collins of New Scotland Yard.

Jorgensen's method became the most accepted system internationally. Beginning in 1914, he gave presentations of the system throughout Europe, and by 1922, many countries agreed to adopt the system and to work together in order to facilitate rapid communication between organizations. American police bureaus were introduced to Jorgensen's system when he traveled to the US in 1922, and they adopted his system the following year at the International Police Conference in New York.

Using a fingerprint examination magnifying glass that he divided into a ruled grid system (**Figure 2**), each sector



A **B** **C**

Figure 1. Three early books on systems developed for transmitting fingerprint details through wireless technology.

of the grid would convey specific information about the overall fingerprint pattern using a total of 50 numerals.

Collins's method **(Figure 3)** was even more complex. An example of the code required for a single fingerprint was: 55070650230550660740430550305066057050506660604402430575040706060202060 9.

For these systems to work properly, an enormous amount of training was required for both the sender and the receiver of the information, and this would be one of the main causes for the undoing of these systems. Moreover, in addition to the complexity of Jorgensen's fingerprint-coding system, he was asking for the "wholesale abandon-

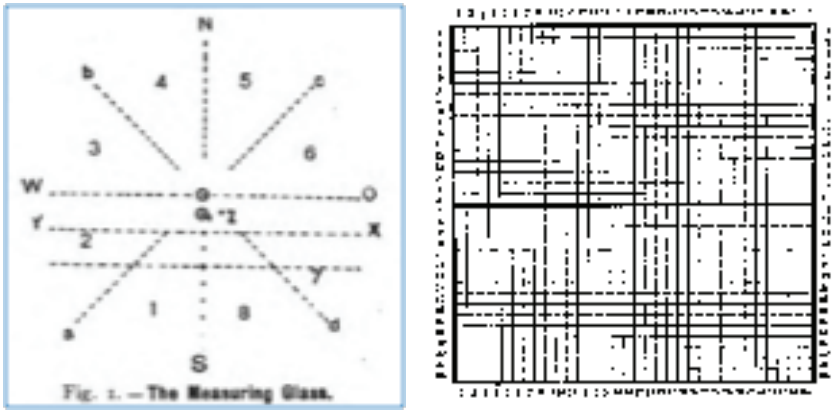


Figure 2. Fingerprint-magnifying glass grid system [*Distant Communication*; 1922; public domain].

ment of twenty or more separate fingerprint classification and filing systems that had already been put in operation at the expense of much time, study and work" [2].

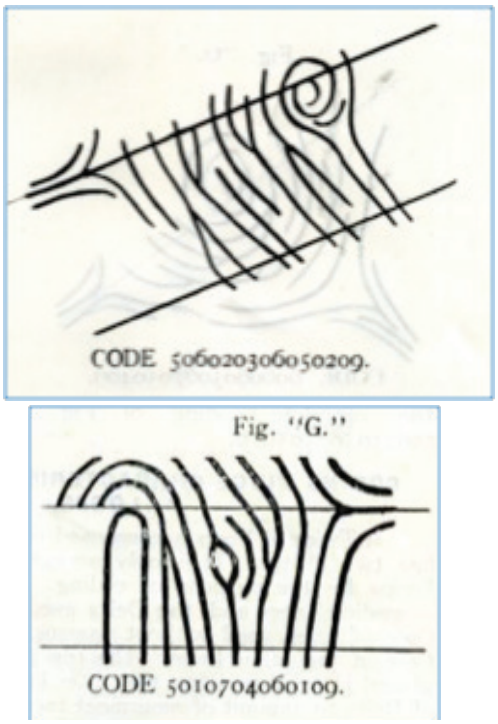


Figure 3. Code generated from partial fingerprint samples [A telegraphic code for finger-print formulae, 1922; public domain]

Photograph-Transmitting Technology

Of course, a technology that would render all of these fingerprint-coding systems obsolete was a system for transmitting photographs wirelessly. Telephotography had actually been successfully demonstrated as far back as 1907, when a German mathematician named Arthur Korn developed a system that transmitted a photograph from Berlin to Paris. In 1908, the photograph of a criminal was telegraphed from Paris to a London newspaper, which published it and the apprehension of the criminal soon followed. A French inventor named Edouard Belin made considerable improvements to telephotography and, in 1921, the first wireless transmission of a fingerprint photograph was completed in Paris **(Figure 4)**. The first transmission of a fingerprint photograph in the US occurred on July 1, 1924, when a photograph was sent from a police bureau in New York to one in Chicago.

Interestingly, Jorgensen was well aware of the work of Belin and telephotography, and when he pitched his system in the United States, he read a statement from the famed French criminologist Edmond Locard advocating the simultaneous use of telephotography and Jorgensen's system [6]. Although telephotography was certainly the technology of the future, Jorgensen's system was certainly more cost effective and practical in that most police bureaus had the means to telegraph information.

Figure 4. First fingerprints sent by telephotography [*Scientific American*; 1922; public domain].

Although Jorgensen's telegraphic fingerprint system would never be implemented and utilized in the manner he had envisioned, his efforts represented the first serious attempt in police history to make criminal identification possible on an international scale.

References

1. Cole S: *Suspect Identities: A History of Fingerprinting and Criminal Identification*; Harvard University Press: Cambridge, MA; 2002.
2. Leonard VA: *Police Communication Systems*; University of California Press: Berkeley, CA; 1938.
3. Wehde A: *Finger-prints Can Be Forged*; The Tremonia Publishing Company: Chicago, IL; 1924.
4. Jorgensen H: *Distant Identification;* Arnold Busck Publishing: Copenhagen, Denmark; 1922.
5. Fingerprints by Radio; *Scientific American*; 122:386; 1922.
6. International Police Conference; Hotel Commodore: New York, NY; April 30–May 5, 1923.

COMMENTARY

Whither Forensic Science Journals?

A. W. Jones
Division of Drug Research, Department of Biomedical and Clinical Sciences
Linköping University
Linköping, Östergötland
Sweden
wayne.jones@liu.se

The title of this commentary is not meant to be derogatory or sarcastic, because I would be the first to acknowledge that science would be hard to imagine without scientific journals. Publishing the results of research and development in journals is how scientists spread new knowledge and information among their peers. Indeed, credit for making a scientific discovery is often determined by the date stamp an article receives when it arrives at a journal for publication [31]. When the article is eventually published, or perhaps these days when it appears on the journal website (on-line), this is tantamount to making the information it contains public property.

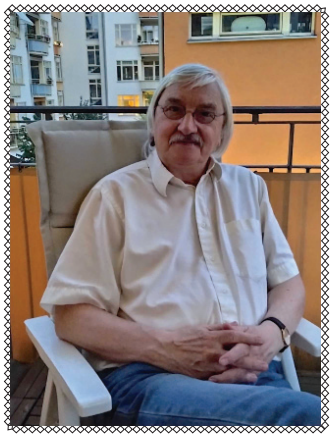
Scientific journals have a long history. One of the first on record dates from 1665, entitled *Philosophical Transactions of the Royal Society of London*. This title still exists and the entire journal archive has been digitalized, thus allowing an article published in the 17th century to be downloaded "gratis" as a high-quality PDF [portable document format] file. Other well-established British journals are *Nature* (founded in 1869) and *The Lancet* (founded in 1823); the former is a general science journal and the latter specializes in medicine, surgery, and therapeutics.

The first edition of *Journal of the American Medical Association* (*JAMA*) appeared in 1883 and *The Boston Medical and Surgical Journal* was founded in 1812 and renamed *New England Journal of Medicine* (*NEJM*) in 1928. The NEJM advanced to become the most influential and highly cited journal in the field of clinical medicine, with an impact factor of 74.7 in 2019.

Forensic Journals

Forensic science is a relatively small scientific discipline, although the first journals to publish articles about legal medicine, crimes, and criminology originated in Germany at the end of the 19th century. One example is *Archiv für Kriminologie* (*Archives for Criminology*), now published by Max Schmidt-Römhild Verlag (Lübeck, Germany), which recently commemorated 120 years of publication; the journal was founded in 1898 and volume 242 appeared in 2020. A forensic medicine journal entitled *Deutsche Zeitschrift für die gesamte gerichtliche Medizin* (*German Journal for Comprehensive Judicial Medicine*) can trace its roots to 1852 [26]. Over the years the journal's name has changed several times, eventually becoming known as *Zeitschrift fur Rechtsmedizin* (*Journal of Legal Medicine*). This served as the official organ of the Deutsche Gesellschaft für Rechtsmedizin (German Association of Legal Medicine: Berlin, Germany). A decision was made in 1990 to create an English language version, which became known as *International Journal of Legal Medicine* (Springer Verlag: Berlin/Heidelberg, Germany). This switch from German to English also saw the creation of *Rechtsmedizin* (*Legal Medicine*), which continued to publish articles mainly in the German language and was supported by the German Association of Legal Medicine [26].

One of the first British journals dedicated to publishing information relevant to forensic science and legal medicine was *Medico-Legal Journal*. Volume 1 appeared in 1904 and



Professor A. W. Jones was born in Wales (UK) but has spent most of his career working in Sweden. He is now retired from his position as senior scientist at the National Laboratory of Forensic Genetics and Forensic Toxicology (Linköping, Sweden). After publishing his first paper in 1974, Dr. Jones has written or co-written some 450 journal articles, reviews, and/or book chapters. He is the sole author on 215 of these items, the first author on 135 articles, and last and corresponding author on 41 others. Dr. Jones's articles have been published in approximately 100 different scientific journals. He serves on the editorial boards of a dozen journals in the fields of forensic and legal medicine and substance abuse and is ad hoc peer-reviewer for another 70 scientific journals. The bulk of Dr. Jones's publications have appeared in Journal of Analytical Toxicology (1983–2020, n = 43), Forensic Science International (1978–2020, n = 43), Journal of Forensic Sciences (1978–2005, n = 21), and Clinical Chemistry (1979–2001, n = 14). According to Google Scholar, Dr. Jones's current H-index is 62 and his Research Gate score is 45.5. Another publication metric is the J-index (n = 9), which means that Dr. Jones has published ≥ 9 articles in each of 9 different journals.

volume 88 in 2020 (Sage Publishing: Thousand Oaks, CA). The first issue of the *Journal of the Forensic Science Society* (*JFSS*) appeared in 1959 and served as the official organ for the UK's Forensic Science Society (Harrogate, UK). In 2001 this underwent a name change to *Science & Justice* (Elsevier: Amsterdam, The Netherlands), but numbering of the volumes continued after the original series in *JFSS*. A journal entitled *Forensic Medicine* appeared in 1960, but shortly afterward received the more interdisciplinary title *Forensic Science*. This eventually became *Forensic Science International* (Elsevier), which is now one of the premier journals in this subject category [14].

The American Academy of Forensic Sciences (AAFS; Colorado Springs, CO) was founded in 1948 and its current membership is close to 6,600, including many members from around the world. The inaugural issue of the *Journal of Forensic Sciences* (*JFS*) appeared in 1956, first a quarterly and later a bimonthly periodical. In January 2020, *JFS*, which is now published by Wiley-Blackwell (Oxford, UK), became an Internet-only journal, the regular printed editions becoming a part of history.

The only current forensic journal devoted to publishing review articles on a broad range of topics is *Forensic Science Review* (*FSR*), which has been doing so for over 30 years (first volume in 1989). Since 2015, each issue of *FSR* has an open-access "Professional Review and Commentary" section that includes (a) recent advances and important events in various branches of the forensic sciences in the United States and around the world; (b) new books and book reviews; (c) a historical perspectives column; and (d) commentaries by senior members of the forensic community.

Journal Impact Factors

A widely used metric to compare and contrast scientific journals and the articles they publish is known as the Journal Impact Factor (JIF). JIF is frequently used by universities and funding agencies to judge the quality of a person's publications in connection with hiring new staff and making decisions about research funding [10,11]. Journals with high JIFs are considered more important and influential in their discipline compared with those with lower JIFs. The JIF is calculated by counting the total number of citations to a journal's articles in a particular year to all material published in the same journal in the previous two years. This citation count is then normalized by dividing by the number of citable items appearing in the journal during the same two-year period [12].

The guru of citation counting was Eugene Garfield (1925–2017), who founded the Philadelphia-based organization Institute for Scientific Information in the 1960s [16]. He developed the principles and practice of citation analysis and coined the term "impact factor". Garfield was a prolific writer and scholar in the field of bibliometrics and information science [6]. Impact is a nice-sounding word and conjures up something impressive or important, and there is no escaping the fact that there is a lot of prestige attached to getting one of your papers accepted for publication in a journal with a high JIF.

When an article published in journal A is referenced in an article published in journal B, then one can say that A is a "cited journal" and B is the "citing journal". Traditionally, JIF was calculated using a two-year publication window. Thus, the 2019 impact factor for a journal is derived by totaling the citations received in 2019 to all material published in the journal in the two previous years (2017–2018). The citations arrived at are then divided by the number of citable items (articles and reviews) appearing in the journal in 2017 and 2018 as shown below:

$$\text{JIF (2019)} = \frac{\text{Citations in 2019 to all material published in 2017 and 2018}}{\text{Number of citable items published in 2017 and 2018}}$$

The traditional two-year JIF might not be so appropriate for "slow-moving" disciplines where there is less pressure to publish, such as in the forensic sciences, because it appears that many practitioners are burdened with routine casework and court testimony and have little time to write papers. If forensic scientists are hesitant to write and publish papers, then they don't get the opportunity to cite papers penned by their peers, which is one reason that forensic journals have relatively low impact factors.

Accordingly, a five-year citation window might be more relevant for forensic science journals when JIF is calculated and this metric is now included in the Clarivate Analytics (Philadelphia, PA, US) journal citation reports. This database contains the citation track records for more than 8,000 scientific journals subdivided into various subject categories. The latest JIFs become available every year in June or July and the publishers of scientific journals as well as the editors eagerly await delivery of their latest ranking.

The latest (2019) JIFs for journals within the subject category "Medicine, Legal" are shown in **Table 1**. There were only 16 journals in this category; topping the list was *Regulatory Pharmacology and Toxicology*, which probably belongs to the discipline of toxicology rather than forensic science and legal medicine. In the table, the forensic journals are ranked according to their 2019 JIFs, which ranged from 2.652 to 0.488. Also shown is the total number of citations to each particular journal's articles, as well as the conventional two-year JIF with and without self-citations. A self-citation occurs when an article appearing in a journal contains a reference to an article previously published in the same journal. Note that the rank ordering of the forensic journals was hardly

Table 1. Ranking of journals within the subject category "medicine, legal" according to the latest (July 2020) version of Clarivate Analytics journal citation reports[a]

Rank	Journal name	All citations	2-Year JIF[b] (2019) WSC[a]	2-Year JIF[b] (2019) NSC[a]	5-Year JIF[b,c]
1	*Regul Toxicol Pharmacol*	6,858	2.652	2.401	2.813
2	*J Law Biosci*	330	2.275	2.196	2.568
3	*Int J Legal Med*	4,573	2.222	1.790	2.193
4	*Forensic Sci Int*	14,388	2.108	1.667	2.264
5	*Sci Justice*	1,348	2.075	1.717	2.430
6	*Forensic Sci Med Pathol*	1,115	1.611	1.397	1.899
7	*Med Law Rev*	385	1.460	1.300	1.404
8	*J Forensic Sci*	8,497	1.441	1.252	1.436
9	*J Forensic Leg Med*	1,952	1.302	1.192	1.444
10	*Legal Med*	1,449	1.195	1.095	1.257
11	*Aust J Forensic Sci*	459	1.188	1.009	1.019
12	*J Law Med Ethics*	1,673	1.085	0.995	1.133
13	*Am J Forensic Med Pathol*	1,657	0.785	0.597	0.826
14	*Med Sci Law*	672	0.676	0.632	0.763
15	*Rechtsmedizin*	335	0.592	0.344	0.497
16	*Rom J Legal Med*	293	0.488	0.393	0.547

[a] *https://www.researchgate.net/publication/342803832_2020_Latest_Impact_Factor_Clarivate_Analytics_Journal_Citation_Reports_Release_of_JCR_Thomson_Reuters* (Accessed October 27, 2020).

[b] Abbreviations: JIF = journal impact factor; WSC = with self-citations; NSC = no self-citations.

[c] 2015–2019.

influenced after adjusting for self-citations. The five-year JIF is also included in the table and, interestingly, there was a high correlation with the conventional two-year JIF (Pearson's r = 0.985).

Journal impact factors vary widely between different scientific disciplines or categories and it would be wrong to compare forensic journals with those, for example, in the field of immunology, oncology, or molecular biology [25]. Furthermore, the JIF refers to citations received by the average article published in a journal and not a specific article. A person might be fortuitous enough to have an article published in *Nature* (2019 JIF = 42.7) or *Science* (2019 JIF = 41.8), but that does not necessarilly mean that your article receives this number of citations. The frequency distribution of JIFs is highly skewed to the right and for convenience have been subdivided into four quartiles, with the most prestigious journals in each subject category belonging to Q1. During the evaluation of a person's work for academic appointments or grant applications, publishing an article in a journal belonging to Q1 is considered more meritorious [9].

If a journal is not included in the *Web of Science* database then it cannot receive an impact factor, which is the case for newly launched journals. The JIF is formally defined below:

> *A journal impact factor is the average number of times that articles published in that journal in the two previous years (e.g., 2018 and 2019) were cited in a particular year (e.g., 2020).*

One problem with the JIF calculation is that the numerator includes citations to all types of material published in a journal, such as news items, editorials, book reviews, letters, and commentary as well as research articles and reviews, whereas the denominator in the JIF quotient only includes substantial material, which consists of original articles, reviews, and short communications. This can sometimes skew the JIF calculation [15].

The Upsurge of Electronic Journals

We are living in a digital age; information and news reports on all kinds of topics are instantly available via the Internet. The plethora of social media that has emerged in the past decade has impacted on society and the relationships between people and information exchange is mind-boggling. Likewise, many scientific journals have become electronic and are only available on-line, and the printed versions are now obsolete.

I believe most people will agree that it is less convenient and practical to read a scientific paper on a computer screen compared with a paper copy, while relaxing in an armchair or sitting behind a desk. However, one problem with receiving the printed version of a journal in a multidisciplinary field like the forensic sciences is that each monthly or bimonthly issue might occupy 200–300 pages of text and include dozens of scientific papers and reports. However, in each issue of a journal there might be only one or two articles of any direct interest or relevance to your particular area of forensic science. This makes it much more convenient to make print copies of the electronic version of articles (in pdf format) and read them "the old-fashioned way."

As already mentioned, the flagship journal of the AAFS became electronic-only from January 2020. The annual page count for *JFS* in 2019 was ~2000 pages (making an average of 333 pages per bimonthly issue). During a long career in science, people accumulate masses of printed matter, which has to be kept somewhere or discarded, which speaks strongly in favour of electronic storage of scientific journals. Print and postage costs are continually rising and the reproduction of colored images, which are very important in some forensic subdisciplines such as pathology, is costly in paper format, but cheap to produce the same material electronically on-line.

The publisher John Wiley (Hoboken, NJ) began publishing an electronic-only journal in 2019 called "*WIREs Forensic Science*", and this represents an important source of information about criminalistics, forensic science, and legal medicine (anthropology, chemistry, biology, medicine,

crime scene investigation, digital sciences, toxicology, and jurisprudence). Because this journal is on-line only, making updates to the articles when new developments and publications appear should be relatively easy and less costly than producing the second edition of a printed book. The content of *WIREs* forensic science series is fully citable, but instead of article page numbers for identification, they employ a digital object identifier (doi).

Another recent addition to forensic science journals is called *Forensic Sciences Research*, which is published by Taylor & Francis (London, UK), and the fifth volume appeared in 2020. The articles it publishes are abstracted in MEDLINE and the *Web of Science*, so this journal will soon receive its first impact factor.

Looking into a crystal ball has never been easy, but my prediction for forensic science and other journals is that more and more will become electronic-only in the future.

Peer Review

Whatever the future holds for scientific journals, one thing is certain: the peer review of manuscripts will survive, because this is indispensable to ensure quality and correctness of the journal content [13]. The peer review of an article before acceptance is generally considered a stamp of approval for the results, conclusions, and opinions expressed by the authors of the article.

However, much might be gained by more transparency regarding the peer-review process, such as by posting the peer-review reports on the journal's website [32]. These reports might be included as supplementary material and posted on-line along with the electronic version of the article. The situation today with most journals is that the peer-review reports are confidential information for the editor's eyes only. If, for example, peer reviewers knew that their signed reviews would be made "open access", that might prompt them to be more diligent, such as by timely completion of the task and weighing up the tone of their comments and critique of the manuscript [7]. In the long run, this might avoid a lot of ill-will that sometimes develops when reviewers make derogatory comments about the quality and structure of a manuscript, because encountering hostile peer reviewers is not uncommon [17].

In the US Supreme Court's ruling in the 1993 opinion *Daubert vs Merrell Dow Pharmaceutical*, the justices emphasized the importance of peer review and publication for admissibility of expert evidence [18]. Their much-quoted criteria for admission included:

- Whether the theory or technique employed by the expert is generally accepted in the relevant scientific community;
- Whether it has been subjected to peer review and publication;
- Whether it can be and has been tested;
- Whether the known or potential rate of error is acceptable; and
- Whether the research was conducted independent of the particular litigation or dependent on an intention to provide the proposed testimony.

After a submitted manuscript is accepted for publication and appears in a journal, it is not possible to know what changes had been made, if any, to the original version of the manuscript submitted. The quality and correctness of all manuscripts improve after being revised based on sensible and constructive comments by two or more peer reviewers. Normally, there are two editorial referees invited to look at the manuscript submitted for publication in addition to the editor, who also sometimes makes suggestions for improvement [30]. Their task is to identify strengths and weaknesses in the work submitted and to spot any statistical errors, inconsistencies, typos, missing or inappropriate literature references, etc. [2].

Peer reviewers are usually given two to three weeks to return their comments to the editor or the editorial office. These reports should be in the form of a numbered list cross-referencing page and line numbers in the manuscript. Most journals also ask for a recommendation about the final disposition of the article, such as "accept as is" (which is very rare), "accept with minor or major revisions", or reject the article outright. If peer reviewers knew that the information contained in their reports "warts and all" will enter the public domain they might be inclined to tone down some of the comments and critique transmitted back to authors [32].

It is also tempting to use a totally open peer-review system, which would mean that the authors get to know the names of the reviewers, who are expected to sign their reports [23]. At the moment, most forensic journals operate a single blind review system; the reviewers know who the authors are, but the authors don't know the names of the referees [19]. A double blind manuscript review entails removing the names and address of the authors from the manuscript before this is sent to peer reviewers [29]. However, the double blind approach is not infallible and the origin of the authors is often disclosed by looking at the list of references. Finding several references to articles written by members of the same laboratory or research group gives a hint about authorship of the current manuscript sent for peer review.

Open-Access Journals

Many prestigious scientific journals have had a policy of "page charges" whereby the authors of an accepted manuscript help to defray some of the publication costs, which might require paying US$50–500 per printed page

occupied in the journal. Some journals expect authors to pay a handling fee of $150–$500 when submitting the manuscript for publication.

In recent years "open access" publications have sprouted up and these seem popular with many journal publishers and editors. This means that if a manuscript receives a favorable peer review and is accepted for publication, the authors are expected to pay a fee, which might amount to several thousand dollars. Thereafter the article is considered "open access", which means that it is in the public domain for all to read, print, or download without a cost involved. US federal government funding agencies stipulate that all published results of research emanating from a funded project (taxpayers' money) must be made "open access". Indeed, a small part of the research grant is earmarked for that specific purpose.

Electronic access to articles that are not open-access is possible via journal home-pages at a certain cost, which might vary from $25–50 per article. The publisher usually furnishes an abstract of the article and sometimes a list of the references without charge. However, the cost of gaining electronic access appears to be the same regardless of whether the article occupies one page in the journal, such as a letter to the editor, or is a 25-page review, which is a bit hard to fathom. Most university libraries have negotiated electronic access to hundreds of scientific journals by making "package deals" with the publisher, which are costly and have been questioned. In an editorial in *Nature*, predatory journals (see next section) were considered to be a corrupting influence on the legitimate open-access journals [1].

Predatory Journals

According to a Google search, the word "predatory" means "seeking to exploit others" and in this connection the victims are scientists and people who write papers and are intent on getting them published [21,28]. When a journal publishes a scientific article, the names of the authors and the e-mail address of the corresponding author enters the public domain. These e-mail addresses are captured by certain individuals and used for unsolicited marketing of commercial products as well as a lot of other things, including threatening letters asking for money. Over the past 10 years, scores of "scientific journals", defined as predatory, have sprouted up and they bombard scientists with requests to submit articles for publication in their journal. They often make flattering remarks about a person's previously published articles and promise rapid publication including peer review of manuscripts, but reading between the lines there is also a charge ranging from $300–$1,000 per article [27].

The geographic origin of these e-mails is not always obvious, but there is evidence pointing toward India, Pakistan, or various parts of Africa [8]. Most of these newer opportunist journals have a homepage, and also list the names of an editor and an editorial board, but many of these individuals are not in the mainstream of scientific publishing or are recognized experts in the subject matter of the journal.

This plethora of e-mails has become a nuisance, because they are never ending; my inbox receives between 10 and 20 such requests daily [4]. They might start with "we are in shortfall" of an article to complete the next issue of our journal, please send us an article, or any material, for rapid publication. The university e-mail servers are often successful in flagging this spam or junk mail, but this folder also needs to be monitored occasionally. Many requests for manuscripts come from journals totally outside my academic interests or specialist area of research.

Concluding Remarks

Forensic science, its practitioners and the research papers they publish, is tightly linked to law enforcement and investigation of crimes and the presentation of scientific evidence as an integral part of the prosecution case [24]. This often entails writing affidavits or depositions under oath or being called to testify in court as an expert witness to explain scientific issues and review the current state of knowledge on some question of relevance in the case. Under the adversarial system of justice, the task of the expert witness is to assist the court and not one of the parties that has hired them to testify. Full disclosure of information is paramount and if there are disagreements or differences of opinion in the relevant scientific community, these need to be admitted and explained to the trier of fact [3]. Unlike ordinary witnesses, the expert witness is permitted to give opinion evidence based on their own experience, training, and skills and also to interpret the published research and opinions of other scientists [22].

Predicting the future for scientific journals is not easy, but it seems to me that "the writing is on the wall" and within the next 10 years, the printed versions of specialist scientific journals will become extinct. There will be some exceptions, such as the weekly periodicals, like *Nature* and *Science*, because besides publishing original research and review articles, each issue contains a lot of other material, such as news, views, opinion pieces, editorial matters, and invited commentary. Furthermore, a personal subscription to one of these journals is not that expensive, especially if an electronic-only option is taken.

About 20 years ago, most universities canceled their subscriptions to printed journals and now offer electronic

access only. Students, researchers, professors, and other teaching staff can no longer skim through the latest issue of their favorite journal. Instead, they can read the articles on a computer screen and download PDF files for storage and printing. These package deals made between major publishers (e.g., Elsevier, Springer, Wiley) and the universities are costly and allow electronic access to hundreds of journal titles [20]. However, there is often a time limit on what material is electronically available, such as the previous 10 years, whereas a journal might have been publishing papers for more than 100 years. Some journals offer electronic access to their entire back catalogue of articles since its foundation, which might be early 19th century. *The Lancet*, for example, allows subscribers to download and print articles published since 1823.

Some of the newer "open access" journals have become very successful, and achieved respectable impact factors. One example is the *PLoS* series of journals, which stands for *Public Library of Science*. This nonprofit organization has created about 10 journals in various subject categories, such as *PLoS Biology*, *PLoS One*, and *PLoS Genetics*.

The vast majority of the so-called "predatory journals" are doomed to failure and people would be advised not to submit their work for publication nor accept invitations to join editorial boards or peer-review manuscripts for them [5].

References

1. Beall J: Predatory publishers are corrupting open access; *Nature* 489:179; 2012.
2. Boughton SL, Kowalczuk MK, Meerpohl JJ, Wager E, Moylan EC: Research integrity and peer review-past highlights and future directions; *Res Integr Peer Rev* 3:3; 2018.
3. Chin JM, McFadden R: Expert witness codes of conduct for forensic practitioners: A review and proposal for reform; *CJLJ* 23:23; 2020.
4. Clemons M, de Costa ESM, Joy AA, Cobey KD, Mazzarello S, Stober C, Hutton B: Predatory invitations from journals: More than just a nuisance; *Oncologist* 22:236; 2017.
5. Cobey KD, Lalu MM, Skidmore B, Ahmadzai N, Grudniewicz A, Moher D: What is a predatory journal? A scoping review; *F1000Res* 7:1001; 2018.
6. Cronin B, Atkins HB (Eds): *The Web of Knowledge: A Festschrift in Honor of Eugene Garfield;* Information Today: Medford, NJ; 2000.
7. Csiszar A: Peer review: Troubled from the start; *Nature* 532:306; 2016.
8. Cukier S, Helal L, Rice DB, Pupkaite J, Ahmadzai N, Wilson M, Skidmore B, Lalu MM, Moher D: Checklists to detect potential predatory biomedical journals: A systematic review; *BMC Med* 18:104; 2020.
9. García JA, Rodriguez-Sánchez RJ, Fdez-Valdivia J, Martinez-Baena M: On first quartile journals which are not of highest impact; *Scientometrics* 90:925; 2012.
10. Garfield E: Journal impact factor: A brief review; *CMAJ* 161:979; 1999.
11. Garfield E: The history and meaning of the journal impact factor; *JAMA* 295:90; 2006.
12. Golubic R, Rudes M, Kovacic N, Marusic M, Marusic A: Calculating impact factor: How bibliographical classification of journal items affects the impact factor of large and small journals; *Sci Eng Ethics* 14:41; 2008.
13. Jana S: A history and development of peer-review process; *Ann Lib Inf Stud* 66:152; 2019.
14. Jones AW: Forensic journals — Bibliometrics and journal impact factors; In Payne-James J, Byard RW (Eds): *Encyclopedia of Forensic and Legal Medicine*, 2nd ed, Vol 2; Elsevier: Amsterdam, The Netherlands; p 528; 2016.
15. Jones AW: Mode of classification of source material as citable items skews journal impact factor calculations; *Scand J Clin Lab Invest* 65:623; 2005.
16. Jones AW: Tribute to Eugene Garfield; *TIAFT Bulletin* 47:29; 2017.
17. Lanier WL: Dealing with inappropriate-, low-quality-, and other forms of challenging peer review, including hostile referees and inflammatory or confusing critiques: Prevention and treatment; *Account Res* 16:1; 2020.
18. Lesciotto KM: The impact of Daubert on the admissibility of forensic anthropology expert testimony; *J Forensic Sci* 60:549; 2015.
19. McGillivray B, De Ranieri E: Uptake and outcome of manuscripts in Nature journals by review model and author characteristics; *Res Integr Peer Rev* 3:5; 2018.
20. McLellan F: Publishers face backlash over rising subscription costs. High prices have led some US institutions to cancel subscriptions to, or even boycott, scientific journals; *Lancet* 363:44; 2004.
21. Memon AR: Predatory journals spamming for publications: What should researchers do? *Sci Eng Ethics* 24:1617; 2018.
22. Milroy CM: A brief history of the expert witness; *Acad Forensic Pathol* 7:516; 2017.
23. Moylan EC, Harold S, O'Neill C, Kowalczuk MK: Open, single-blind, double-blind: Which peer review process do you prefer? *BMC Pharmacol Toxicol* 15:55; 2014.
24. O'Brien E, Nic Daeid N, Black S: Science in the court: Pitfalls, challenges and solutions; *Philos Trans R Soc Lond B Biol Sci* 370(1674):20150062; 2015.
25. Pendlebury D: The use and misuse of journal metrics and other citation indicators; *Arch Immunol Ther Exp* 57:1; 2009.
26. Puschel K, Lach H, Turk E, Pollak S: The centenary of the german association of legal medicine — From its foundation in 1904 to 21st century legal medicine; *Forensic Sci Int* 144:285; 2004.
27. Shamseer L, Moher D, Maduekwe O, Turner L, Barbour V, Burch R, Clark J, Galipeau J, Roberts J, Shea BJ: Potential predatory and legitimate biomedical journals: Can you tell the difference? A cross-sectional comparison; *BMC Med* 15:28; 2017.
28. Sorokowski P, Kulczycki E, Sorokowska A, Pisanski K: Predatory journals recruit fake editor; *Nature* 543:481; 2017.
29. Tomkins A, Zhang M, Heavlin WD: Reviewer bias in single-versus double-blind peer review; *Proc Natl Acad Sci USA* 114:12708; 2017.
30. Wager E, Parkin EC, Tamber PS: Are reviewers suggested by authors as good as those chosen by editors? Results of a rater-blinded, retrospective study; *BMC Med* 4:13; 2006.
31. Vale RD, Hyman AA: Priority of discovery in the life sciences; *Elife* 5:e16931; 2016 (doi: 10.7554/3Life.16931); *www.ncbi.nlm.nih.gov/pmc/articles/PMC4911212* (Accessed October 27, 2020).
32. van Rooyen S, Delamothe T, Evans SJ: Effect on peer review of telling reviewers that their signed reviews might be posted on the web: Randomised controlled trial; *BMJ* 341:c5729; 2010.