Forensic Sci Rev 33:79–115
July 2021

Professional Review and Commentary[a]

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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.

Forensic Science in Canada

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Canada is the world's second largest country by area — almost 10 million square kilometers (3.85 million square miles) — but it contains barely 38 million people [1]. Governmental responsibilities for the provision of forensic science services across the sprawling Canadian federation are reflected in the constitutionally mandated policing, official investigative, and justice system roles for the federal government, based in the capital city of Ottawa, and for the 10 provincial and 3 territorial legislatures. While provincial and territorial governments are primarily responsible for municipal and provincial policing services, significant portions of these services across the country are actually performed by the federal Royal Canadian Mounted Police. This cooperation between the federal and provincial/territorial governments in providing policing services is mirrored in the delivery of related forensic science services, where a federal laboratory system services those police forces that lack their own provincial, territorial, and First Nations forensic laboratories.

Forensic science services in Canada have evolved largely from medical and academic institutional beginnings to today's highly centralized, and mostly publicly funded, systems, distinct from the more extensive but splintered system in the neighboring US. Perhaps in response to having to contend with Canada's relatively scattered population over a large geography, as well as a social history and constitutional culture of "peace, order and good government" [2]. Canada's forensic science landscape is largely dominated by the "big three" publicly funded forensic laboratories. These are the Centre of Forensic Sciences (CFS) in the province of Ontario, the Laboratoire de sciences judiciaires et de medicine légale (LSJML) in the province of Québec, and the federally funded Royal Canadian Mounted Police National Forensic Laboratory Service (RCMP-NFLS), the latter providing forensic services to police and official investigative services in the remaining eight provinces and three territories.

The Forensic Laboratory System in Canada

The history of Canada's forensic laboratory system and its leading scientists is well documented, and the author would like to acknowledge the significant contribution to this body of literature published by the *Canadian Society of Forensic Science Journal* (*J Can Soc Forensic Sci*) and, in particular, reviews authored by Dr. Douglas Lucas, past director of the Centre of Forensic Sciences in Toronto.

Federal Public Laboratories

The ***Royal Canadian Mounted Police National Forensic Laboratory Service*** provides forensic biology, firearms and tool marks, toxicology, and trace services, as well as an anticounterfeiting bureau. RCMP forensic laboratories across Canada are currently organized across facilities in three cities, Ottawa (Ontario), Surrey (British Columbia), and Edmonton (Alberta) [3]. At different times from 1937 to the present, RCMP forensic laboratories were also established, although subsequently closed, in Sackville (New Brunswick), Vancouver (British Columbia), Edmonton (Alberta), Winnipeg (Manitoba), Halifax (Nova Scotia), and Montreal (Quebec).

The first RCMP "Crime Detection Laboratory" was established in Regina, Saskatchewan (in 1937) by Dr. Maurice Powers, initially providing investigative assistance in chemistry, firearms and ballistics, body fluid analysis, and questioned documents [4]. This laboratory system grew in size and scope, including the development of a separate toxicology section as well as various forensic databases; these include an automotive paint database [5] and the Canadian Integrated Ballistics Identification Network (CIBIN) for evidence leads in firearms investigations.

There are more than 70 RCMP Forensic Identification Services (FIS) units across Canada providing police-based forensic identification services — including crime scene processing, trace and biological evidence collection, bloodstain pattern analysis, and pattern comparison analyses (including fingerprint, footwear, and tire tracks) — to RCMP detachments as well as to provincial and municipal police services requiring these services [6].

The RCMP has the sole responsibility for the National DNA Databank (NDDB) [7] based in Ottawa. Beginning in 2000, the NDDB first consisted of a Convicted Offender Index (COI) and a Crime Scene Index (CSI) of short tandem repeat (STR) DNA profiles. CSI profiles are produced and uploaded by the CFS, LSJML, and RCMP public laboratories, while the COI samples are ordered, post-conviction, by judges in cases of legislatively des-

ignated offenses and analyzed by the RCMP laboratory system. STRDNA profiles are stored and searched within the Combined DNA Index System (CODIS), a software provided by the US Federal Bureau of Investigation. Canada has the largest CODIS network outside of the US [8]. The NDDB has expanded technical services to include Y-STR and mitochondrial DNA analysis and has also added the following indices for use in humanitarian investigations: Missing Persons Index, Relatives of Missing Persons Index, Human Remains Index, and Volunteer Donor Index [9].

Other federal government laboratories provide specialized forensic science services. The Laboratory and Scientific Services Directorate (LSSD) is the Ottawa-based scientific branch of the Canada Border Services Agency (CBSA) [10]; it provides forensic science expertise in document examination as well as the detection and analysis of contraband substances. Health Canada (HC) provides forensic scientific and technical services to law enforcement agencies in the identification and quantification of illegal drug evidence [11].

Provincial Public Laboratories and Forensic Science Services

Ontario and Quebec have the largest provincial populations and are the only two provinces in Canada with dedicated provincial government forensic science laboratories.

The Centre of Forensic Sciences (CFS) is an agency of the Ontario Ministry of the Solicitor General; it operates forensic science laboratories in the cities of Toronto and Sault Sainte Marie [12]. The CFS provides expertise and analysis services to police and official investigative agencies in forensic toxicology, biology and DNA, chemistry, documents, and firearms and tool marks. Well before government-organized forensic services, forensic science in Ontario began in the mid-1800s with a small number of physicians and academics who began assisting the justice system. Chemistry professor Henry Croft (University College, Toronto) reported a finding of arsenic in an 1859 murder case, and William Ellis, also a chemistry professor (Trinity College, Toronto) testified in court cases involving serological and hair evidence in the late 1800s [13]. Professor Joselyn Rogers, described as a "one-man crime lab" [14], was instrumental in expanding the scope of forensic alcohol testing and toxicology services in Ontario in the first half of the 20th century.

The government of Ontario created the Attorney General's Laboratory in 1951 in the provincial capital of Toronto, under the directorship of Dr. H. Ward Smith [15]. This laboratory was renamed the Centre of Forensic Sciences in 1966 and moved to the jurisdiction and oversight of the Ministry of the Solicitor General of Ontario in 1972. The CFS expanded in 1992 with the addition of a satellite laboratory in Sault Sainte Marie to service the large, though sparsely populated, northern portion of the province of Ontario; the Toronto laboratory moved its operations, as well as those of the offices of the Chief Coroner and Forensic Pathology, to a new facility, the Forensic Services and Coroner's Complex, in that city in 2013.

The Laboratoire de sciences judiciaires et de medicine légale [16] (LSJML; Laboratory of Forensic Sciences and Forensic Medicine) in Montréal is an agency of the Ministère de la Sécurité publique (Ministry of Public Security) in the province of Quebec. It offers expertise and scientific analyses in forensic ballistics, biology, chemistry, documents, digital images, toxicology, and legal medicine [17]. Founded as L'Institut de Médicine Légale (Institute of Legal Medicine) in 1914 by Dr. Wilfrid Derome, it was the first facility of its kind in North America, providing expertise in forensic medicine, chemistry, and physics. Since that time, and under the leadership of forensic science innovators, including Drs. J-M Roussel and Rosario Fontaine, the scope of forensic testing at the Institute (renamed LSJML) broadened to include biology and genetics, toxicology, ballistics, counterfeiting, electronic and computer engineering, odontology, and anthropology [18]. The Institute was instrumental in organizing the first congress of the Canadian Society of Forensic Science, held in Montréal in 1954, and the laboratory celebrated its 100th anniversary in 2014. The LSJML expanded its mandate in 1996 to offer forensic services to the private and para-public sectors [19].

Death Investigations

The constitutional responsibility for death investigations across Canada falls under provincial jurisdiction, and this responsibility varies in operation among the Canadian provinces and territories. Some provinces have instituted a medical examiners system, where forensic pathologists not only perform the autopsies but also lead the death investigations. Other provinces have a coroners system, where forensic pathologists perform autopsies at the order of the provincially appointed coroner; the coroner may or may not be a pathologist, depending on the individual provincial statutes. In all provinces, ancillary expert assistance from forensic anthropologists, entomologists; odontologists mostly from medical and academic communities; and laboratory assistance from the associated provincial or federal forensic laboratory. Noting differences among the provinces in case selection criteria for investigation and the qualifications of pathologists and investigators, Kelsall and Bowes [20] suggested improving death investigations by instituting an overarching Canadian authority to develop and implement national training programs, practice benchmarks as well as credentialing and accreditation systems.

Police Identification Units

Processing crime scenes — in particular, documenting, photographing, collecting, and sampling evidence — is performed by police identification units within the various municipal, provincial, and national police forces across Canada. These units are staffed primarily by sworn police officers, but some of the larger units are also staffed by additional civilian scene-of-crime officers (SOCOs) or forensic identification assistants. Police identification officers perform various forensic tests, including pattern analyses of tread marks, friction ridges, digital and cybercrime forensics, and bloodstain pattern analysis. Forensic identification training for police officers occurs at the RCMP Canadian Police College in Ottawa, the École nationale de police du Québec, and the Ontario Police College (Aylmer, Ontario).

Private and Academic Forensic Laboratories

A number of universities house forensic laboratory facilities that provide casework assistance as well as managing academic research activities. The Natural Resources DNA Profiling and Forensic Centre of Trent University (Peterborough, Ontario) offers casework expertise in wildlife DNA analysis [21]. The British Columbia Institute of Technology (BCIT) Forensic DNA Laboratory [22] provides forensic DNA analysis, including unidentified human remains cases with highly degraded samples. Simon Fraser University, also in British Columbia, operates the Centre for Forensic Research [23], providing casework and research expertise in areas including entomology, anthropology, DNA, and botany.

There are private laboratories throughout Canada, too numerous to list comprehensively, performing forensic evidence-testing services in both criminal and noncriminal casework, including defense testing of evidence in criminal cases, DNA kinship analysis in child and family services as well as immigration kinship cases, cannabis regulatory testing, toxicology analysis, wildlife DNA analysis, and many other forensic applications. A small number of these private laboratories are accredited under the ISO/IEC 17025 general requirements for the competence of testing and calibration laboratories; these laboratories include Wyndham Forensic Group [24] and TheDNALAB (Bureau Veritas Laboratories) [25], both based in Guelph, Ontario.

Regulation and Standards

There is no provincial or federal legislation in force in Canada requiring forensic science laboratories to maintain the ISO/IEC 17025 general requirements for the competence of testing and calibration laboratories; however, accreditation is met voluntarily by the major public and some of the private Canadian forensic laboratories. A federal agency — Immigration, Refugees and Citizenship Canada (IRCC) — accepts DNA test results for immigration and citizenship applications as evidence of kinship, but only recognizes test results from laboratories accredited by the Standards Council of Canada (SCC) [26].

The SCC, based in Ottawa, acts as an accrediting body for the purpose of laboratory accreditation. Its general mandate includes the promotion of voluntary standardization, where such standardization is not required by Canadian federal or provincial legislation [27]. In terms of forensic disciplines, the SCC offers accreditation in biology and DNA analysis, toxicology, chemistry and trace analysis, counterfeits, drug (including equine drug) chemistry, explosives, firearms and tool marks, and questioned documents [28].

In 2018, the legislature of the Province of Ontario passed a law mandating forensic laboratory accreditation, largely in response to a number of miscarriages of justice in that province. The *Forensic Laboratories Act* [29] provides that

> *"No person shall, in a laboratory, conduct a test to which this section applies, unless, (a) the laboratory is accredited, by an accrediting body prescribed by the regulations, to a prescribed general standard; and (b) if the test is a prescribed test, the laboratory is accredited, by an accrediting body prescribed by the regulations, to a prescribed standard for that test."*

At the time of writing of this review, regulations determining the scope of the prescribed tests covered by this legislation have not been published, and the *Forensic Laboratories Act* has not yet come into effect in Ontario.

Two special committees of the Canadian Society of Forensic Science provide forensic toxicology expertise and advice to the federal government in developing standards and regulations. The Alcohol Test Committee [30] (ATC, formerly known as the Breath Test Committee) assists the federal Department of Justice in evaluating alcohol test equipment and making recommendations for use for the purpose of the Criminal Code of Canada (CCC) [31]. Similarly, the Drugs and Driving Committee [32] (DDC) evaluates drug-screening equipment and protocols and also advises the Department of Justice on CCC amendment purposes [33].

Education and Research

Forensic Science in Canada

A Report of Multidisciplinary Discussion (2012) [34] identified major trends driving changes in the Canadian forensic science community:

- A shift to an evidence-based paradigm;
- A recognition of the need to bridge a gap between expectation and deliverables in expert opinions; and
- The continuing influence of the US agencies such as the National Academy of Sciences (NAS).

While the authors did not recommend the creation of new agencies and major reforms to the extent described in the American 2009 NAS report [35], they did highlight systemic problems and made numerous recommendations to develop and improve a cycle of "service, teaching and research" in Canadian forensic science. They stressed the need for a national granting agency to fund forensic science research, and, related to this, improvements in the forensic science research culture at universities, including the establishment of research chairs in forensic science disciplines. In terms of areas for potential research, they targeted statistical and probabilistic approaches to problems of the weight of evidence in the forensic sciences. The authors recognized the reality of the relatively low number (and geographically scattered nature) of Canada's population, and the challenges of Canadian forensic scientists and academics to effectively network. They observed that academic forensic science training programs experience a lack of coordination in terms of content and standards, and made numerous recommendations to improve forensic science education, including the development of master's and doctoral-level, forensic science research-focused degrees.

Canadian Society of Forensic Science (CSFS)

The CSFS mandate is "to promote the study, raise the standards and enhance the stature of forensic science as a distinct discipline" [36]. This volunteer-run professional organization, founded in 1953 and incorporated in 1963, has promoted forensic science education and research through the funding of research and scholarships, publishing the *J Can Soc Forensic Sci*, and organizing educational meetings. Notwithstanding organizational challenges of bringing together members of a relatively small forensic science community scattered throughout a large country, as well as incorporating its bilingual (French and English) mandate, the CSFS has run regular education conferences for the dissemination and sharing of information in forensic anthropology, biology, chemistry, documents, engineering, firearms, medical, odontology, and toxicology. These conferences have been on-site, most recently in 2016 in Montreal and 2018 in Ottawa, but began to move on-line in 2020 due to COVID-19 restrictions. The CSFS has also established rules of professional conduct and a disciplinary process for members.

Forensic Science Programs in Canadian Postsecondary Academic Institutions

Specialized forensic science training and forensically focused research programs are relatively new and welcome additions to academic offerings in Canadian postsecondary institutions. Depending on the institution, these programs offer university undergraduate and graduate degrees as well as college certificates. The degrees or certificates range from general forensic science training to specialized degrees or certificates in niche fields, such as digital and computer forensics.

University Programs in Forensic Science[a] [37]

The introduction of university-level forensic science programs has led to the development of focused forensic science research programs that are able to target scientific issues of consequence to the Canadian climate and justice system, as well as partner with both government and private forensic casework laboratories in defining and organizing research projects. These programs also assist in training student graduates to enter forensic-related jobs in policing, laboratories, and research.

Programs offering both undergraduate and graduate degrees in, or related to, forensic science, and also carrying out graduate and/or postgraduate student forensic science research, are now available across Canada, but mostly concentrated in the central provinces of Ontario and Quebec. These include the Ontario institutions of Laurentian University (Sudbury, ON) [38], the University of Toronto (Toronto, ON) [39], Ontario Tech University (Oshawa, ON) [40], and Trent University (Peterborough, ON) [41]. The University of Windsor (Windsor, ON) [42] offers undergraduate degrees in forensic science, as does the Université du Québec à Trois-Rivières (Trois-Rivières, QC) [43], the latter being the site of Canada's first "body farm" for taphonomic research. On the west coast, the British Columbia Institute of Technology (Burnaby, BC) [44] and the University of British Columbia — Okanagan (Vancouver, BC) [45], offer undergraduate degrees in forensic science. Simon Fraser University (Burnaby, BC) [46] offers a certificate in forensic studies. On the east coast, St. Mary's University (Halifax, NS) [47] offers a certificate program in forensic science as well as a graduate degree in forensic psychology.

College Programs

Certificates in forensic-related fields, including forensic identification, digital/computer forensics, and forensic health disciplines, are offered by a number of college institutions, including Fleming College (Peterborough, ON) [48], Humber Institute of Technology & Advanced Learning (Toronto, ON) [49], and Lambton College (Sarnia, ON) [50].

Select Miscarriages of Justice Cases in Canada

The *Criminal Code of Canada* provides the framework for a ministerial case review on the grounds of a miscarriage of justice [51]. The federal Minister of Justice has the authority to order a new trial or to refer the matter to the relevant provincial or territorial Court of Appeal. The Criminal Conviction Review Group (CCRG) investigates applications in order to make recommendations to the Justice Minister in this process [52]. Innocence Canada (formerly the Association in Defense of the Wrongfully Convicted) [53] and various innocence projects at Canadian

[a]This summary does not include programs in forensic psychiatry or pathology specifically associated with medical school programs across Canada.

law schools work to assist in the preparation of documents for submission to ministerial reviews.

Similar to many other countries, Canada has experienced a number of miscarriages of justice that exposed various forensic science and justice system failings. Rather than setting up permanent government commissions, as is the situation in various American jurisdictions, Canadian governmental responses to miscarriages of justice have tended toward appointments of judges or retired judges to lead temporary ad hoc commissions. Three of these miscarriage of justice cases are of particular importance in terms of the changes they brought about in Canadian forensic science.

Kaufman Commission (1996) [54]

Justice Archibald Kaufman was tasked by the Government of Ontario to investigate and make recommendations following the wrongful conviction of Guy Paul Morin in the 1984 homicide of a young girl. The Crown prosecution's case included the identification of trace amounts of blood in the defendant's car, as well as hair and fiber comparison evidence. Justice Kaufman made 35 recommendations regarding the laboratory protocols and expert testimony. These recommendations included the requirement for forensic scientists to adhere to the scientific method, and to work to disprove, rather than prove, a hypothesis. With respect to expert testimony, Justice Kaufman stressed that expert opinions should be acted upon by investigators only if in writing, and he recommended the improving education of all justice system participants in the limitations of forensic science testing. He recommended monitoring expert court testimony as part of the implementation of a laboratory-wide quality assurance system. He highlighted potentially troublesome and misleading terminology, such as "indications of blood" for the results of presumptive testing (Recommendation 4: "Evidence of a preliminary test, such as an 'indication of blood,' does not have sufficient probative value to justify its reception at a criminal trial as circumstantial evidence of guilt"), and "match" and "consistent with" for hair and fiber evidence (Recommendation 5: " Where hair and fibre comparison evidence or other scientific evidence is tendered as evidence of guilt, the trial judge would be well advised to instruct the jury not to be overwhelmed by any aura of scientific authority or infallibility associated with the evidence and to clearly articulate for the jury the limitations upon the findings made by the experts"). Mr. Morin was eventually exonerated by DNA evidence, and the true killer was recently determined through the use of forensic genealogy [55].

Motherisk Commissions (2015) [56] *and (2018)* [57]

From the 1990s to the middle of 2015, the Motherisk Drug Testing Laboratory (DTL) at the Hospital for Sick Children in Toronto performed drug identification and quantification testing on hair shaft samples, first for research and clinical purposes, but eventually also for forensic purposes in criminal and child protection cases. This laboratory was accredited to medical, but not forensic, standards. In the wake of a 2014 criminal case [58] that exposed potential test result and testimony reliability issues at that laboratory, the government of Ontario established the Motherisk Hair Analysis Independent Review. Justice Susan Lang, leading this review, reported a number of flaws in the Motherisk DTL laboratory and practices that called into serious question the reliability of the toxicology reports and testimony. These flaws included reporting unconfirmed qualitative and quantitative results from preliminary screening (ELISA, enzyme-linked immunosorbent assay) tests, the lack of written standard operating procedures, the absence of appropriate proficiency testing, and a paucity of oversight of the DTL by the hospital administration. In her 2015 review, Justice Lang concluded that the laboratory's testing and operations fell "woefully short of internationally recognized forensic standards".

In response to Justice Lang's report, the Ontario government established a second commission under the leadership of Justice Judith Beaman, *Harmful Impacts: The Reliance on Hair Testing in Child Protection: Report of the Motherisk Commission*. Justice Beaman's report set out a roadmap to implement the process of restorative justice to the numerous persons and families adversely affected by the Motherisk laboratory actions. She did not make specific recommendations for change for forensic science providers, but did stress the necessity to work to enhance "the ability of the court and lawyers to screen out suspect or unproven testing methods and to ensure that the court is aware of the possibility of false positives, bias, or other problems with evidence." The Ontario provincial legislature responded to the two commissions by passing the *Forensic Laboratories Act* (see above) requiring relevant accreditation to laboratories performing forensic work, but this law has yet to come into force in that province. No other province, as of the writing of this review, has introduced similar legislation.

Goudge Inquiry (2008) [59]

The *Inquiry into Pediatric Forensic Pathology*, under the direction of Justice Steven Goudge, was created by the Ontario government in response to numerous wrongful criminal convictions that occurred due to faulty forensic pathology evidence in child homicide cases. Justice Goudge made specific recommendations for improving forensic pathology practice, focusing on enhancing legal training for forensic pathologists to assist them in understanding their role in the justice system, implementing a code of conduct and effective oversight of the work and testimony of pediatric pathologists, and improving programs of training and certification of forensic pediatric pathologists. In response, the Ontario government reorganized forensic pathology services with the implementation of the Ontario Forensic Pathology Service (OFPS) to oversee forensic pathology investigations throughout the province.

Justice Goudge's recommendations have a bearing on all areas of forensic science in Canada. Of note, in Chapter 18 of his report, Justice Goudge delved into the issue of the justice system's ability to effectively assess the reliability of expert evidence. He reviewed American and Canadian case law on this subject and provided a comprehensive list of criteria for the assessment of expert evidence reliability; finally, he recommended that judges "vigilantly" exercise their gatekeeper responsibility. Justice Goudge's insights into determining the reliability of forensic evidence have played a role in the evolution of Canadian expert evidence case law. For example, in the case of *Regina v. Abbey* [60], the Ontario Court of Appeal endorsed a two-step process for evaluating the reliability, and therefore admissibility, of expert evidence. The first step is the traditional assessment of the threshold relevance and necessity of the evidence, as well as the expert qualifications, following the framework provided by the Supreme Court of Canada in *Regina v. Mohan* [61]. The second step is a Goudge inquiry-influenced cost/benefit assessment of the proposed expert opinion in the particular case, where the trial judge decides whether expert evidence that meets the *Mohan* preconditions to admissibility is still sufficiently beneficial to the trial process to warrant its admission.

Concluding Remarks

There are no indications that Canada's centralized system of government-run forensic laboratory service delivery will significantly change in the near future. However, the forensic science landscape in Canada continues to evolve in response to multiple forces, including calls for change stemming from miscarriages of justice and the various Canadian and American governmental responses to such events. In addition, not all of the publicly funded forensic laboratories are mandated to provide scientific services for noncriminal cases, and a growing number of private forensic laboratories fill an ever-increasing demand to provide such services and expertise for civil and regulatory matters. The "big three" publicly funded laboratory systems are government, or "Crown", institutions, and private laboratories and experts also fulfill a growing demand for independent assistance and expertise in an adversarial criminal justice system where the prosecution is also an arm of the Crown. Most recently, Canadian forensic science capability and expertise has expanded and matured with the introduction of many dedicated postsecondary academic programs in forensic science education and research.

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The Forensic Science System in Hungary

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Historical Development (The Past of Forensic Science in Hungary)

The development of criminalistics (or more broadly forensic science) in Hungary started shortly after the introduction of the term "criminalistics" by Hans Gross, an Austrian investigating judge and university professor (widely recognized as the "father" of forensic science), in his ceremonial work entitled, *Handbuch für Untersuchungsrichter als System der Kriminalistik*, published in 1893 [1]. Historical development events are summarized in **Table 1** with fuller illustration provided below.

Books and Journals. Based on the work by Hans Gross, the first university textbook on criminalistics was published in Hungary in 1897 [2]. In 1959, László Vargha, a university professor and internationally renowned forensic handwriting expert from Pécs, became the first scholar in Hungary to be awarded a scientific candidate's degree (PhD) in criminalistics by the Hungarian Academy of Sciences [13]. Since then, more than 60 scholarly monographs have been written by Hungarian authors on topics related to criminalistics.

A comprehensive 730-page manual covering both criminal techniques and criminal tactics was published in 1961 [5]. Even a university coursebook for law students was published in 1965, edited by László Vargha [6]. After several university course books, the first Hungarian manual and atlas-textbook on criminalistics was published for law students in 2005; it was developed further and supplemented with 200 color images by the authors [9]. In 2004 a comprehensive two-volume encyclopedia on criminalistics was published, featuring descriptions by 36 criminalists of forensic science progress in their respective subfields [10]. In 2019, a law enforcement encyclopedia, also comprising a wide range of entries on forensic sciences, was compiled at the National University of Public Service [11].

In 1953, the professional journal *Rendőrségi Szemle* (*Police Review*) was launched. In the same year, the Criminal Technical Institute was set up within the Ministry of the Interior for conducting forensic research and high-priority inquiries [4]. The Institute gave an account

Table 1. Important events related to the development of forensic science in Hungary

Event category	Event	Year	Ref.
Book & journal	Publication of the first textbook on criminalistics (by Hans Gross of Austria)	1893	[1]
	Publication of the first textbook on criminalistics (in Hungary)	1897	[2]
	Criminalistics textbook (in Hungarian)	1936	[3]
	Launching the journal "*Rendőrségi Szemle*" (*Police Review*)	1953	[4]
	Publication of a textbook for the police law enforcers	1961	[5]
	Publication of a textbook for the law students	1965	[6]
	Launching the journal "*Bűnügyi Technikai Közlemények"* (*Criminal Technical Communications*)	1969	[7]
	Launching the journal *"Főiskolai Figyelő"* (*College Observer*)	1971	[8]
	First Hungarian textbook and atlas on criminalistics	2002	[9]
	Two-volume encyclopedia on forensic sciences	2004	[10]
	Enlarged textbook and atlas for law students	2005	[9]
	Publication of an encyclopedia on law enforcement	2019	[11]
Educational institution & event	Setting up the Police Academy	1948	[12]
	Setting up the Crime Museum	1957	[12]
	First PhD (former Academic) level in the field of criminalistics	1959	[13]
	International symposium on criminalistics held in Budapest	1966	[14]
	Setting up Police College	1971	[15]
	International symposium on criminalistics held in Siófok	1981	[14]
Technology & laboratory	Fingerprint registry	1903	[3]
	National registry of forensic scientists	1954	[12]
	Establishing National Institute of Criminalistics	1960	[13]
	Setting up a police dog training school (near Budapest)	1964	[17]
	Application of profiling of dynamic traces	1976	[18]
	Setting up the Automated Fingerprint Identification System	1979	[19]
	Innovation of Recoware: palm print identification system (Recoderm)	1992	[20]
	The first Hungarian DNA identification	1992	[21]
	Introduction of profiling methodology	1995	[22]
	The first "cold hit" (from the database) DNA-identification in a murder case	2012	[23]

of its own research results annually in the journal *Bűnügyi Technikai Közlemények* (*Criminal Technical Communications*), launched in 1969 and edited by Imre Kertész [7]. The Police College (established in 1971 as a successor to the Police Academy) issued regular publications of new ideas and developments relating to the theory and practice of forensic science in the frames of the journal *Főiskolai Figyelő* (*College Observer*) [8].

Education and Research. Following World War II, in 1948, the Police Academy was set up for the training of criminalists at a national level. Since 1954 we can speak of the actual establishment of the currently existing organization of forensic experts, comprising (a) expert institutes operating in the frames of universities; (b) experts recorded in the registry of experts kept by the Ministry of Justice; and (c) experts attached to law enforcement agencies. In 1957 the Crime Museum was set up, which became entirely open also to outside visitors following the democratic political transition of 1989 [12].

In 1960 the National Institute of Criminalistics, the members of which studied and conducted high-level research into the theory of criminalistics, was started. The fact that the institute was organizationally attached to the prosecution service rendered it possible for it to establish and maintain closer relations with the whole justice system. The institute published its most significant forensic research results annually [16].

The science of criminalistics (forensic science) was introduced in 1961 among the subjects taught at several law faculties in Hungary. In 1966, an international symposium on criminalistics was held in the Hungarian capital, Budapest, followed by another symposium in Siófok (a tourism destination on the southern shore of Lake Balaton) in 1981 [14]. Meanwhile the Police College since its 1971 establishment was becoming a prominent training school for law enforcers [15].

Technology and Laboratory. In 1903, a fingerprint registry (the first in continental Europe) was established by Hungarian law enforcers, based on the British model. This was followed by the foundation of various forensic laboratories. The activities of these laboratories were also reflected in a comprehensive work published in 1936 [3]. In 1964, a police dog training school was set up in the town of Dunakeszi near Budapest, where intensive training has taken place for identifying, tracking, trace identification, and human remains detection [17].

In the early 1970s, a research group of experts elaborated the application of profilography (profiling) in the investigation of dynamic traces [18]. This was followed by the introduction of the Automated Fingerprint Identification System (AFIS), based on the American model [19]. In 1992, the Hungarian innovation of RECOWARE, a palmprint identification system (Recoderm) was presented; in a worldwide first, Recoderm was used for palm identification in a real-life criminal case in Hungary in 1994 [20]. Also, in 1992, with the help of the technique developed by British expert Alec Jeffreys in 1985–1986, the first DNA analysis and personal identification were carried out [21]. In 2012, in the case of the murder of Kata (Catherine) B. from the city of Pécs, for the first time in Hungary, a (murder) perpetrator was identified — with the help of the DNA database — by way of comparison of the perpetrator's material trace recorded (fixed) at the crime scene ("cold hit" identification) [23].

In the 1990s — based on US experience — first the elaboration, then the application, of the new methodology of profiling was started, followed by the analysis and application of digital electronic data in criminal investigation in the 2000s [22].

Present Organizational Frames (the Current Status of Forensic Science in Hungary)

Networks of experts are systematically built to help seek factual and truthful revelations of the past. Lists of institutions, universities, and journals are presented in **Table 2,** reflecting the current status of forensic science in Hungary. Further details are illustrated below.

Forensic Science Institutions. As a successor to the Criminal Technical Institute (founded in 1953), the National Expert and Research Centre of Budapest carries out innovative research covering the whole country through its modern equipment park and highly qualified experts. As a member of the European Network of Forensic Science Institutes (ENFSI) [24], this organization provides expert opinions in criminal and civil cases in 67 different specialty areas — in the frames of quality assured, accredited procedures, and in compliance with international standards and professional rules. These areas include, among others, finger [25] and other marks, weapons, ammunition, and numerous trace materials (e.g., DNA) [26].

Outside the capital, there are 11 territorial institutes operating all over the country [27]. At county seats there are separate expert institutes, where experts with a minimum of 10 years' professional experience are providing opinions in the fields of accounting, technology, and agriculture [28]. In addition, there are (usually private) experts recorded in the registry kept by the Ministry of Justice actively operating in almost every walk of life [29] (in the field of electricity, workplace accidents, air transport, banking transactions, etc.) [30].

Table 2. The current status of forensic science in Hungary

Category	Name	Ref.
Institutions	National Expert and Research Centre in Budapest	[24]
	(finger and other marks, weapons, ammunitions, traces, DNA)	[25,26]
	11 territorial (forensic) institutes	[27]
	County institutions with forensic experts (account, technology)	[28]
	Private experts (registered by the Ministry of Justice)	[29,30]
Universities	Forensic medical institutes	[31]
	National University of Public Service (training for forensic experts)	[32]
	8 law faculties at universities have criminalistics education	[33]
Journals	Belügyi Szemle (Interior Review)	[34]
	Magyar Rendészet (Hungarian Law Enforcement)	[34]
	Rendőrségi Tanulmányok (Policing Studies)	[34]
	Kriminológiai Tanulmányok (Criminological Studies)	[34]
	Magyar Jog (Hungarian Law)	[34]
	Bírák Lapja (Judges' Journal)	[34]
	Ügyészek Lapja (Prosecutors' Journal)	[34]
	Ügyvédek Lapja (Lawyers' Journal)	[34]
	Nemzetbiztonsági Szemle (National Security Review)	[34]
	Jogelméleti Szemle (Journal of Legal Theory)	[34]
	JURA (published by the University of Pécs Faculty of Law)	[34]

Universities. Within individual universities, there are forensic medical institutes that provide their positions on matters relating to crime against life and property, crime related to alcohol and drugs, crime-related personal identification (face reconstruction), and postmortem examinations [31]. At the National University of Public Service, future criminal (investigating) professionals in several vocational fields (police, tax, and customs) are trained at university level (BSc, MSc, PhD). The preparation of law enforcement officers also extends to the training of forensic experts, which fits into the university-level law enforcement training as a postgraduate specialist training program [32]. At eight Hungarian law faculties, intending judges, prosecutors, and lawyers can study criminalistics (forensic science) and they can also participate in the national conference on criminalistics held annually in the city of Pécs [33].

Journals. Apart from the journal *Belügyi Szemle* (*Interior Review*) — the successor of the journal *Rendőrségi Szemle* (*Police Review*) — which also publishes essays on criminalistics (forensic science), one may also read academic articles in: (a) *Magyar Rendészet* (*Hungarian Law Enforcement*), a journal attached to the National University of Public Service; (b) *Rendőrségi Tanulmányok* (*Policing Studies*), a journal edited by the Central Police Station of Baranya County; (c) *Kriminológiai Tanulmányok* (*Criminological Studies*), a journal published by the National Criminology Institute; and (d) occasionally in the following journals: *Magyar Jog* (*Hungarian Law*), *Bírák Lapja* (*Judges' Journal*), Ügyészek *Lapja* (*Prosecutors' Journal*), Ügyvédek *Lapja* (*Lawyers' Journal*), *Nemzetbiztonsági Szemle* (*National Security Review*), *Jogelméleti Szemle* (*Journal of Legal Theory*), *Jog-Állam-Politika* (*Law-State-Politics*), and *JURA*, a periodical published by the Faculty of Law of the University of Pécs [34].

The Role and Participation of Forensic Scientists in Legal Proceedings [35]

Currently, the investigating authority, the prosecutor's office, and the court may appoint an expert witness to ensure the success of the criminal proceedings. Among them are forensic scientists, who most often give evidence-based answers to factual questions in trace, weapons, writing, identification, and medical questions. The end result of their opinion can be categorical (confirmatory or exclusionary) and probabilistic (according to its several degrees). In the course of his work, the forensic scientist is entitled to:

- Know all the data necessary for the performance of his task;
- Get acquainted with the file;
- Be present at acts of prosecution;
- Request information from the seconding authority, the accused, the victim or the witness;
- View and examine material means of proof and electronic data;
- Carry out sampling;
- Work together with several experts and give a joint opinion;
- Use illustrative means to explain at the hearing; and
- Receive remuneration for his job.

In serving their functions in the legal proceeding, forensic scientists are also required to observe their duties as summarized below:

- To deliver a thorough, nonbiased opinion in a timely manner;
- Not to cause damage to the condition of the items under examination, nor to destroy them;
- To use the latest scientific methods;
- To present findings at the hearing;
- To answer questions from the court, prosecution, and defense; and
- To supplement expert opinions if necessary (and if ordered).

Authorities, including ultimately the court, evaluate and weigh the opinion of forensic scientists with respect to the evidence. They very often have a strong weight in establishing or finding of guilt and excluding guilt, respectively.

Future Possibilities (Future Development of Forensic Science in Hungary)

In this section an attempt is made to outline the future possibilities for the theoretical and practical development/ improvement of criminalistics that may affect Hungarian forensic research and crime detection practice. On the technical aspect, these developments include:

- Exploration of the molecular structure of human scent (scentmap) and its identification test with an instrument (replacing scent identification by dogs) [36];
- Application and development of layered voice analysis [37], the method of digital voice identification [38], the computer-based graphometry for personal identification [39]; and
- The superprojection (superimposition) procedure [40] and the Bayes analysis [41].

On the tactical aspect, potential efforts include:

- The introduction in Hungary of the psychological stress evaluation instrument (PSE) [42];
- The institution of forensic nursing (nurse) [43] and the "digit commandoes" [44];
- Application and development of the thermal camera method in lie detection[45]; and
- Development of graphoprofiling [46], geographical (mapping) information system (GIS) [47], and digit-evidence investigation [48].

Concluding Remarks

At the end of the essay, it is to be noted as a consciousness-raising thought that even if all our prophesies (prognoses, presentiments) and suggestions should turn into reality and technology, digitalization, computers, and natural and social sciences were to join hands, it would not be possible to replace or find a substitute for the criminalist as a truly indispensable prerequisite for the future success of forensic science. The professional, the explorer, the data collector, the taker of risks and dangers, the facer of continuous challenges, the effective detective, the "crime fighter", the "great warrior" on the seemingly incessant and infinite real and virtual battlefield, equipped with just one weapon: "The Forensic Sciences — An International Treasure" [49].

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The Forensic Science System in Poland

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Forensic experts play an important role in civil, administrative, and criminal proceedings in Poland, helping courts and law enforcement in establishing facts and discovering relevant factual connections. It should be mentioned that in Poland there is an inquisitorial criminal justice system, in which the court is actively involved in investigating the facts of the case while the defendant and his or her attorney have limited possibilities concerning the process of proof. This manifests itself in the fact that the evidentiary value of expert opinions depends on whether the experts are appointed by law enforcement or judicial authorities or are hired privately by case parties. As a general rule, in both criminal and civil procedures, expert opinions and testimony constitute admissible evidence when their source is a court-appointed forensic expert. Such opinions and testimony are allowed to be used as proof regardless of whether the information provided is reliable and scientifically valid. On the other hand, the opinions of partisan forensic experts do not automatically constitute self-sufficient evidence (Article 195 of the Polish Code of the Criminal Procedure [1]; Article 278 of the Polish Code of Civil Procedure [2]). Such opinions are typically regarded as potential sources of evidential information needing to be cross-checked. Thus, legal formalities may prevail over the reliability of an expert's findings, which sometimes hinders the pursuit of truth[a].

Institutions and Regulations

In Poland, forensic examinations are performed by different institutions, both state-funded and private, as well as individual, ad hoc forensic specialists. There are several state-funded forensic institutions:

- Central Forensic Laboratory of the Police (CFLP) and its regional branches within the national police forces;
- Departments of forensic sciences in other law enforcement agencies, such as the Forensic Bureau of the Internal Security Agency (FB ISA) or National Custom Service;
- Institute of Forensic Research of Prof. Jan Sehn in Cracow (IFR);
- Forensic Accounting Institute in Łódż; and
- Departments of forensic medicine at the Polish medical universities and institutes.

CFLP, IFR, and FB ISA are members of the European Network of Forensic Science Institutes (ENFSI) and, as such, are following best practices manuals and guidelines developed within ENFSI. CFLP and IFR are certified according to the PN-EN ISO/IEC 17025:2005 standard[b].

Most forensic examinations are being conducted by nongovernmental forensic experts either employed or hired ad hoc by the private forensic science service providers. The reason is that state-funded forensic institutions have been unable to cope with an ever-growing number of criminal and civil cases and guarantee the timely delivery of expert opinions. Moreover, there is a deficiency of governmental forensic experts in specific fields — above all, environmental forensics [3] and digital data forensics.

Among the most notable private forensic service providers in Poland is the Polish Forensic Science Society in Warsaw. Founded back in 1973, the Society is recognized as the professional body for forensic practice in the country and abroad. It provides forensic service to courts and law enforcement entities, as well as private individuals; promotes and develops regulation in forensic science and practice; and contributes to research in the field of forensic sciences and education. One of the latest achievements of the Society is specialized computer software assisting in handwriting forensic analysis — GLOBALGRAF. The software serves to verify structural and quantitative characteristics of handwriting including signatures, thus contributing to the objectivity of the analysis.

Unfortunately, the Polish forensic services market is generally self-regulated. There is no dedicated legal act

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[a]In the case regarding the murder of minor M. K., the main suspect (T. K.) was accused and later sentenced to 15 years of imprisonment based on the opinion of the forensic experts in the field of odontology. 13 years later a new forensics examination using currently available forensic techniques found that the first expert opinion was erroneous and scientifically invalid. Nonetheless, this opinion was accepted by the courts (first-tier and second-tier tribunals) since it had been produced by court-appointed forensic experts: WYROK W IMIENIU RZECZYPOSPOLITEJ POLSKIEJ: Sygn. akt V KO 26/18; Dnia 16 maja 2018 r. [The Judgement of the Polish Supreme Court of May 16, 2018 in the case V KO 26/18]; *http://www.sn.pl/sites/orzecznictwo/orzeczenia3/v%20ko%2026-18-1.pdf* (Accessed March 10, 2021).

[b]The information about certificates can be found on their official Internet pages: Instytut Ekspertyz Sądowych imienia profesora Jana Sehna w Krakowie — System Jakości [The Institute of Forensic Research in Kraków]; *https://www.gov.pl/web/ies/system-jakosci* (Accessed March 10, 2021); and Centralne Laboratoium Kryminalistyczny Policji — Certyficaty [Central Forensic Laboratory of the Police]; *https://clkp.policja.pl/clk/system-jakosci/certyfikaty/10660,Certyfikaty.html* (Accessed March 10, 2021).

concerning its functioning. The lack of an adequate legal framework encourages some highly questionable practices, such as the outsourcing of forensic examinations to third parties by the court-appointed experts, the prevalence of price and timely delivery over quality and scientific reliability [4], and the risk of the phenomena of "dry-labbing" and "cherry-picking"[c].

It should be mentioned though that last year there were public consultations on a draft law on forensic experts in Poland submitted by the Ministry of Justice. According to the draft law, IFR would be tasked with the regulation of the forensic service market in the country. The director of IFR would be responsible for carrying out the assessment and verification of the forensic experts' competence and skills. The draft introduces mandatory certification and the compilation of the data on forensic experts into a national database. Moreover, the director may revoke the certificate not only for unethical behavior but for the issuing of faulty opinion as well. The main criticism of these propositions concerns the probability that IFR as one of many forensic service providers in the country may use its new power to restrict fair competition and reduce competition. Researchers are also pointing to the fact that under the draft IFR would be obliged to certify the experts and forensic service institutions (providers) in the fields, which lay beyond its competence, such as forensic psychiatry or medicine.

Forensic Scientists

There are two types of private forensic experts: registered (listed, judicial) forensic experts and unregistered (ad hoc) forensic experts. Lists of judicial forensic experts are maintained by the presidents of the district courts (there are 45 courts, and the same number of lists). The judicial expert may be a person who:

- Has a full civil and civic act capacity;
- Has attained the age of 25 years;
- Has the knowledge in a given field, as well as practical skills and professional experience;
- Swears to perform the duties of judicial expert conscientiously and responsibly; and
- Can produce documentary evidence showing that he or she meets the above-mentioned criteria [5].

However, there are several burning issues. First of all, under the current legislation, there are no obligatory exams and certification procedures concerning private forensic experts. It does not even matter whether a candidate has the ability and the equipment necessary to conduct entrusted examinations. Since the presidents of the district courts are lawyers, they are often unable to thoroughly check a candidate's competence and qualifications.

It should be noted that a registered forensic expert can be removed from the list if it turns out that he or she is incompetent or cannot perform his or her tasks properly. However, because there is no uniform list of judicial experts in Poland, such a person may remain on other lists in another district court. In practice, cases where a judge or a third party file a motion to remove an expert from a list due to unethical behavior or incompetence are quite rare [6].

A court-appointed expert may as well be an unlisted self-employed practitioner if he or she, in the court's or investigators' opinion, possesses comprehensive knowledge, experience, and practical skills in the respective fields.

References

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[c]The term "dry-labbing" refers to the act of supplying fictional, plausible results by a forensic expert who did not perform any examinations, or s performed only part of necessary examinations to reduce costs and time. The term "cherry-picking" in this regard means that the forensic expert is selecting only the evidence that is favorable to his or her initial assumptions. Both these practices are not only ethically wrong but may result in erroneous opinions that raise the very real issue of possible miscarriages of justice. See Solodov I: *Etyka biegłego w procesie karnym* [*Ethics for Forensic Experts in Criminal Proceedings*]; Stopka: Łomża, Poland; pp 176–179l; 2016; see also: Projekt "Forensic Watch". Kompetencje biegłych sądowych — oczekiwania i kryteria oceny przegląd rozwiązań stosowanych w różnych państwach i systemach prawnych (The Forensic Watch Project: The Competence of the Forensic Experts in Poland — Expectations and Evaluation Criteria); pp 30–31; 2015; *http://forensicwatch.pl/pliki/Forensic_Watch_Desk_Research.pdf* (Accessed March 10, 2021).

Forensic Science Educational Programs (VIII) — Programs in Australia and New Zealand[a]

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In the last 20 years, there has been an explosion of forensic science educational programs in Australia and New Zealand, although there has been some contraction more recently. This paper aims to capture the range of forensic-related courses currently offered in Australia (**Table 1**) and New Zealand (**Table 2**), including graduate, postgraduate and research options. The review focuses on traditional forensic science programs; however, it should be noted that postgraduate research opportunities would allow specialization in a broad range of forensic disciplines. Inclusion in this paper does not constitute endorsement of the program and no review of the program content has been undertaken.

Forensic science refers to the application of accepted scientific principles to the detection, recognition, collection, analysis, and interpretation of trace, in order to answer questions relevant to the justice sector (including police, courts, coronial matters, security, and civil matters). A strong understanding of the underpinning scientific principles is vital to developing expertise and applying those principles in the forensic analysis processes within the various disciplines. Scientific principles include the development and testing of hypotheses, method validation and verification (including foundational validity and validity as applied), use of controls, application of critical thinking, and understanding limitations and assumptions in any forensic analyses.

Academic institutions approach education in forensic science in different ways. Some institutions focus on the application of forensic science within a scientific context at the undergraduate level, while others focus on educating students about underpinning scientific principles at the undergraduate level, with a specific focus on the application of forensic science at the postgraduate level. Forensic disciplines also have different expectations of the level of study required for progression to developing expertise. Some disciplines such as crime scene, fingerprints, and firearms require undergraduate studies in general forensic science, followed by a postgraduate diploma (or equivalent) in the specific discipline. Other disciplines related to biology (e.g., DNA analysis) and chemistry (e.g., drug analysis, chemical trace evidence analysis) require a relevant undergraduate science degree; however, competition in recruitment processes often results in higher education levels being required to maintain competitiveness.

Any academic qualification will be followed by intensive in-house training in order to fully apply the forensic processes or underpinning scientific principles to the analysis and interpretation of trace and be recognized as a discipline expert. For some disciplines, such as anthropology, the number of experts is very small; therefore, in order to address the need for extensive discipline-specific training, a Ph.D. is required for recognition as an expert. There is no national accreditation program for forensic science education programs in Australia or New Zealand; however, there are numerous ways in which the various academic institutions offering forensic science programs seek to make their programs attractive to potential students. Some academic institutions have sought accreditation through a United Kingdom accreditation program or a specific discipline organization or assessment body. Different universities also have focused on different areas of specialization, such as chemistry, biology, or anthropology. Others have concentrated on applied forensic science, with practicals on crime scene analysis, photography, and fingerprints.

Several academic institutions enjoy strong beneficial relationships with operational forensic laboratories, where expert practitioners provide presentations/lectures or may co-supervise students in later research years. This can be important for postgraduate research where some students are offered the opportunity to conduct their research within the operational laboratory environment. This has advantages for both the laboratory (operationally relevant research, training potential future practitioners, and direct knowledge transfer of research outcomes) and the student (experience working in an operational laboratory, access to forensic practitioners, and enhanced learning outcomes). Regardless of the academic institution chosen, it is important that any prospective student assess the academic program, including an assessment for sufficient content in scientific principles and discipline alignment to a potential future career pathway.

[a]The author would like to thank the representatives of the academic institutions of Australia and New Zealand who provided the information on educational programs contained in this paper.

Table 1. Forensic science educational programs in Australia

Institution[a]; address; department/school; website	Contact information[a]	Degree/course title[b]	Program emphasis[c]
Bond University 14 University Drive, Robina, Queensland 4226 Faculty of Health Sciences and Medicine *https://bond.edu.au/future-students*	1800 074 074; +61 7 5535 1024	PhD (research)	Postgraduate research opportunities
Canberra Institute of Technology 37 Constitution Avenue Australian Capital Territory 2601 Science and Environment *https://cit.edu.au/courses/science_environment/forensics*	infoline@cit.edu.au	BFS (crime scene exam.) Cert IV (biometric technologies) Diploma of forensic ident.: document exam.; biometrics Diploma of forensic invest. Advanced diploma of forensic invest. Advanced diploma of public safety: fire invest. Graduate cert (crime scene invest.; forensic fingerprint invest.; forensic firearm exam.)	Applied forensic sci. qualification, a strong focus toward industry-based training
Curtin University Kent Street, Bentley, Western Australia 6102 School of Molecular and Life Sciences *https://scieng.curtin.edu.au/schools/school-of-molecular-and-life-sciences/*	S. Lewis; s.lewis@curtin.edu.au	BS (sci.), chem. major[b-1,b-2]	Forensic & anal. chem. stream within chem. major of BS; possible to do a minor in forensic studies[c-1]
Specific units of study in Forensic Science *http://handbook.curtin.edu.au/units/32/322260.html* *http://handbook.curtin.edu.au/units/31/316853.html* *http://handbook.curtin.edu.au/units/31/316653.html*		PhM; PhD (research)	Postgraduate research opportunities
Deakin University Geelong Waurn Ponds, 75 Pigdon Road Geelong, Victoria 3216 Faculty of Science, Engineering & the Built Environment *https://www.deakin.edu.au/course/bachelor-forensic-science*	M. Harvey; michelle.harvey@deakin.edu.au A. Durdle; a.durdle@deakin.edu.au 1800 693 888; myfuture@deakin.edu.au	BFS[b-3]; BFS (Honours)[b-3] BFS[b-3]/BCrim[b-3] PhD (research)	General forensic sci. & two majors (chem. & bio.); if doing a single degree (not conjoint with BCrim) can effectively take both streams Research in forensic sci.
Edith Cowan University 270 Joondalup Drive, Joondalup, Western Australia 6027 School of Medical and Health Sciences *http://www.ecu.edu.au* *https://www.ecu.edu.au/degrees/courses/bachelor-of-science-biomedical-science* *https://www.ecu.edu.au/future-students/course-entry*	134 328; +61 8 6304 0000 enquiries@ecu.edu.au Online[a-1]	BS (biomed. sci.) BCrim & Justice	Major general forensic sci.
Griffith University 170 Kessels Road, Nathan, Queensland 4111 School of Environment and Science *https://www.griffith.edu.au/study/science-environment/forensic-science?location=dom*	forensic-programdirector@griffith.edu.au	BFS; BFS (Honours) BFS/BCrim & criminal justice Graduate cert (crime scene invest., police only; forensic fingerprint invest., police only) Master (by research); PhD (research) BS (forensic sci.; Honours); MS (forensic sci.)	General forensic sci. Major[c-2] Postgraduate research opportunities Online course
La Trobe University Plenty Road and Kingsbury Drive Bundoora, Victoria 3086 *https://www.latrobe.edu.au/* *https://www.latrobe.edu.au/study/apply/research*	1300 135 045 *https://latrobe.custhelp.com/app/home*	Honours research Master's (by research) PhD (research)	Postgraduate research opportunities

Table 1. Continued

Institution[a]; address; department/school; website	Contact information[a]	Degree/course title[b]	Program emphasis[c]
Monash University 65 Kavanagh Street, Southbank, Victoria 3006 Department of Forensic Medicine *https://www.monash.edu/medicine/sphpm/forensic/department-of-forensic-medicine*	Mnhs-forensicmedicine@monash.edu	Forensic medicine (Diploma; Graduate cert; Master's)	Forensic medicine, forensic odontology, forensic sci. (medical)
Murdoch University 90 South Street, Murdoch, Western Australia 6150 Medical, Molecular and Forensic Sciences *https://www.murdoch.edu.au/study/courses/undergraduate/bh-fbt* *https://www.murdoch.edu.au/study/courses/postgraduate/c1131* *https://www.murdoch.edu.au/study/courses/postgraduate/g1085* *https://www.murdoch.edu.au/study/courses/postgraduate/m1255* *https://www.murdoch.edu.au/study/courses/postgraduate/m1292*	B. Chapman; Brendan.chapman@murdoch.edu.au	BS (forensic bio. & toxicol.) Forensic sci. professional practice (Graduate cert; Graduate diploma; MFS) MFS (professional practice & research)	Undergraduate: forensic biology & toxicol. Postgraduate: forensic field sci.; forensic chem.; forensic bio.; research
The Flinders University of South Australia Bedford Park, South Australia 5042 College of Science and Engineering *https://www.flinders.edu.au/* *https://www.flinders.edu.au/study/courses/bachelor-science-forensic-analytical-science*	P. Kirkbride[a-2]; Paul.kirkbride@flinders.edu.au A. Linacre[a-3]; Adrian.linacre@flinders.edu.au	Forensic & anal. sci. (BS; BS, Honours)	Two streams: forensic bio.; forensic chem.
The University of Queensland St Lucia, Brisbane, Queensland 4072 School of Biomedical Sciences *https://biomedical-sciences.uq.edu.au/* *https://biomedical-sciences.uq.edu.au/research/groups/human-craniofacial-and-skeletal-identification*	sbms@enquire.uq.edu.au	Honours research Master's (by research) PhD (research)	Forensic anthropol., including: skeletal ident.; craniofacial ident.; radiographic comparison; other forensic anatomy
The University of Sydney City Road Camperdown Darlington, New South Wales 2006 *https://www.sydney.edu.au/*	1800 793 864; +61 2 8627 1444	Master's (by research) PhD (research)	Postgraduate research opportunities
The University of Western Australia M420, 35 Stirling Highway Crawley, Western Australia 6009 Centre for Forensic Anthropology *https://www.uwa.edu.au/able/research/centre-for-forensic-anthropology* *https://www.uwa.edu.au/study/courses/master-of-forensic-anthropology*	D. Franklin; +61 08 64881232; Daniel.franklin@uwa.edu.au	Forensic anthropol. (Graduate cert; Graduate diploma; Master's; Master's, research) PhD (research)	Forensic anthropology
University of Adelaide North Terrace, Adelaide, South Australia 5005 School of Biological Sciences *https://researchers.adelaide.edu.au/profile/jeremy.austin* *https://sciences.adelaide.edu.au/research/research-facilities/advanced-dna-identification-forensic-facility*	J. Austin; Jeremy.austin@adelaide.edu.au	Honours research; MS (research); PhD (research) Projects collaboration with Forensic Science SA	General forensic sci.
School of Medicine	R. Byard; roger.byard@adelaide.edu.au	Master's (by research); PhD (research) Online courses[b-4]	Forensic pathology
University of Canberra University Drive Bruce, Australian Capital Territory 2617 Faculty of Science & Technology Centre for Forensic Studies *https://www.canberra.edu.au/*; *https://www.canberra.edu.au/coursesandunits/course?course_cd=142JA*	study@canberra.edu.au	BAS (forensic studies) Graduate cert (forensic security) Forensic studies in forensic sci., online (Graduate cert; Master's; Postgraduate diploma)	Forensic chem.

Table 1. Continued

Institution[a]; address; department/school; website	Contact information[a]	Degree/course title[b]	Program emphasis[c]
University of New England Armidale, New South Wales 2351 *https://handbook.une.edu.au/aos/2021/FORSC001*	AskUNE@une.edu.au	BS (forensic sci.)	General forensic sci.
University of Tasmania Churchill Avenue, Hobart Tasmania 7005 School of Social Sciences Tasmanian Institute of Law Enforcement Studies (TILES) *www.utas.edu.au/courses* *https://www.utas.edu.au/tiles/forensic-studies*	L. Howes; Loene.Howes@utas.edu.au	Individual forensic studies units[b-5] Honours research Master's (by research) PhD (research)	Generalist understanding of how forensic science is used in society well as studies in forensic sci. as a social phenomenon
University of Technology Sydney 15 Broadway, Ultimo New South Wales 2007 Centre for Forensic Science *http://www.forensics.uts.edu.au*	cfs@uts.edu.au	BFS; BFS (BA in international studies); BFS (Bachelor of creative intelligence & innovation); BFS (Bachelor of laws); BFS (Honours); BFS (Bachelor of laws, Honours) MFS; MFS (extension); MPFS Forensic sci. (Graduate diploma; Graduate cert) MS (research); PhD (research)	Emphasis[c-3]
Western Sydney University Hawkesbury Campus, Bourke Street Richmond, New South Wales 2753 School of Science *https://www.westernsydney.edu.au/*	science@westernsydney.edu.au	BS (forensic sci.) Forensic sci. (Graduate cert; Graduate diploma) MFS MS (research) PhD (research)	General forensic sci. with emphasis on crime scene invest.

[a] Contact information.
[a-1] *https://www.ecu.edu.au/future-students/course-entry*.
[a-2] *https://www.flinders.edu.au/people/paul.kirkbride*.
[a-3] *https://www.flinders.edu.au/people/adrian.linacre*.
[b] Abbreviations of degrees/course titles: BA = bachelor of arts; BAS = bachelor of applied science; BCrim = bachelor of criminology; BFS = bachelor of forensic science; BS = bachelor of science; Cert = certificate; MFS = master of forensic science; MPFS = master of philosophy in forensic science; MS = master of science; PhD = doctor of philosophy; PhM = master of philosophy.
[b-1] *https://study.curtin.edu.au/offering/course-ug-chemistry-major-bsc-science--mjru-chemi*.
[b-2] Chemistry major has accreditation from Royal Australian Chemical Institute.
[b-3] Both programs are accredited by The Chartered Society of Forensic Sciences (UK). Chemistry major also has Royal Australian Chemical Institute accreditation.
[b-4] First year (12 weeks): Introduction to Forensic Sciences; second year (4 weeks): Practical Applications of Forensic Sciences; third year (12 weeks): Topics in Forensic Sciences.
[b-5] Undertaken within Arts degrees as part of a major in criminology, and in policing (professional honors), justice studies, or other degrees (as electives).
[c] Program emphasis information.
[c-1] *https://study.curtin.edu.au/offering/course-ug-chemistry-major-bsc-science--mjru-chemi*.
[c-2] Students must choose one major in chemistry (with additional foundation courses in forensic-related content as well as courses in forensic chemistry) or biology (with additional foundation courses in forensic-related content as well as courses in forensic biology). Elective courses include archaeology courses.
[c-3] General education in forensic science emphasizing the field as a distinctive discipline; Bachelor level provides general Forensic Science education with majors in crime scene investigations, forensic chemistry, forensic biology and digital forensic science; Honours level provides research training with professional specialisation with expert evidence presentation and criminology & policing; Master level and other postgraduate degrees expand knowledge and practice of forensic science alongside developing science management and leadership skills; Double degrees provide education in forensic science combined with another discipline; Doctoral degree provides research training.

Table 2. Forensic science educational programs in New Zealand

Institution[a]; address; department/school; website	Contact information	Degree/course title[b]	Program emphasis[c]
Auckland University of Technology 55 Wellesley Street East, Auckland 1010 Computer Science Department *https://www.aut.ac.nz/courses/bachelor-of-science/molecular-genetics-major-bachelor-of-science*	+64 800 288 864 Online[a]	BS Master of infor. security & digital forensics	Information security & digital forensics
The University of Auckland Private Bag 92019, Victoria Street, West Auckland 1142 Faculty of Science *https://www.auckland.ac.nz/en/study/study-options/find-a-study-option/forensic-science.html*	D. Elliot; douglas.elliot@esr.cri.nz G. Miskelly; g.miskelly@auckland.ac.nz	PGD in forensic sci. MS PhD (research)	Postgraduate education in: forensic chem.; forensic bio.; forensic statistics; general forensic sci. PhD & MS provide research training
University of Canterbury 20 Kirkwood Avenue, Upper Riccarton Christchurch 8041 College of Science *https://www.canterbury.ac.nz/science/qualifications-and-courses/undergraduate/forensic-science/*	+64 3 369 3999; info@canterbury.ac.nz *https://www.canterbury.ac.nz/science/contact-us/international-enquiries/*	BS in psychol.; biochem.	Sci. & psychol. focus
University of Otago 362 Leith Street, Dunedin 9016 Division of Sciences *https://www.otago.ac.nz/courses/subjects/fors.html* *https://www.otago.ac.nz/sciences/study/applied-science/index.html*	J. Stanton; +64 3 479 7483; jo.stanton@otago.ac.nz	BAS	General forensic sci.
Victoria University of Wellington PO Box 600, Wellington 6140 Faculty of Science *https://www.wgtn.ac.nz/sbs/study/subjects/forensic-science*	+64 4 463 5339 course-advice@vuw.ac.nz science-faculty@vuw.ac.nz	BS	Course subjects offered as a minor as part of a global exchange — undertaken at the National Univ. of Singapore

[a] *https://www.aut.ac.nz/study/study-options/engineering-computer-and-mathematical-sciences/courses/master-of-information-security-and-digital-forensics*.
[b] Abbreviations of degrees/course titles: BS = bachelor of science; BAS = bachelor of applied science; MS = master of science; PhD = doctor of philosophy; PGD = postgraduate diploma.

COVID-19 and Early Release of Prisoners: Implications and Future Perspective

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Historically, infectious diseases have spread rapidly in prisons. For example, "gaol fever" (epidemic typhus) greatly increased mortality rates in English prisons for centuries until reforms started to take effect in the 19th century. More recently, in 1997 and in 2001, Russia released prisoners suffering from tuberculosis which prevented that disease's reemergence [1]. Given the rapid-spreading nature of Coronavirus Disease 2019 (COVID-19), small spaces like jails, prisons, and ships are ideal places for its proliferation. World Health Organization (WHO) guidelines recommend that both health agencies and custodial agencies practice control, prevention, and treatment of COVID-19, while sharing information about it directly with WHO.

The simultaneous spread of flu with COVID-19 is even more terrifying in prisons. Flu shots are already in short supply and this is a serious concern in the COVID-19 situation. Only a very small number of jails have the ability to provide flu shots at regular intervals. Many jails and prisoners did not even have the H1N1 vaccine at the time of that outbreak; the vaccine was provided late in 2011 by the medical facilities contributing to the outbreak [1,2].

There are various mediating factors for the transmission of diseases such as COVID-19 in prisons. They include the ages of prisoners, the air within prison environments, and cell sizes in prisons. While improving the general hygiene of prisons and prisoners it is essential to screen, test, and isolate both staff and prisoners in the event of positive COVID-19 tests [3]. Since closed environments such as prisons are some of the most disease-prone environments, priority should be given to prisoners. Differences in prisoner-release policies all over the world emerged due to the lack of any prison-specific guidelines from WHO. However, lowering the pressure of overcrowding by releasing inmates was presumed to mitigate the spread of the virus.

Early Release of Prisoners Around the World During the COVID-19 Pandemic

Prisoners Released in Africa. In various African countries, more than 60,000 prisoners have been released due to the COVID-19 pandemic. South Africa has released 19,000 prisoners while Morocco, Ethiopia, and Mozambique have each released more than 5,000 prisoners during this period [4]. Other countries in Africa have released fewer prisoners, as mentioned in **Figure 1**A.

Prisoners Released in Asia. Till September 2020, approximately 0.5 million prisoners have been released across Asia during the COVID-19 pandemic. Iran, Iraq, and Turkey have released more than 100,000 prisoners during this time period followed by India and Indonesia, which have released more than 50,000 prisoners [5–7]. Numbers of prisoners released in other Asian countries are included in Figure 1B.

Prisoners Released in Europe. Since the COVID-19 pandemic, more than 25,000 prisoners have been released in Europe. According to data through September 2020, more than 5,000 prisoners had been released in France. In addition, Northern Island and Italy have each released more than 2,500 prisoners [8,9]. Figure 1C shows totals of prisoners released in some other countries of Europe.

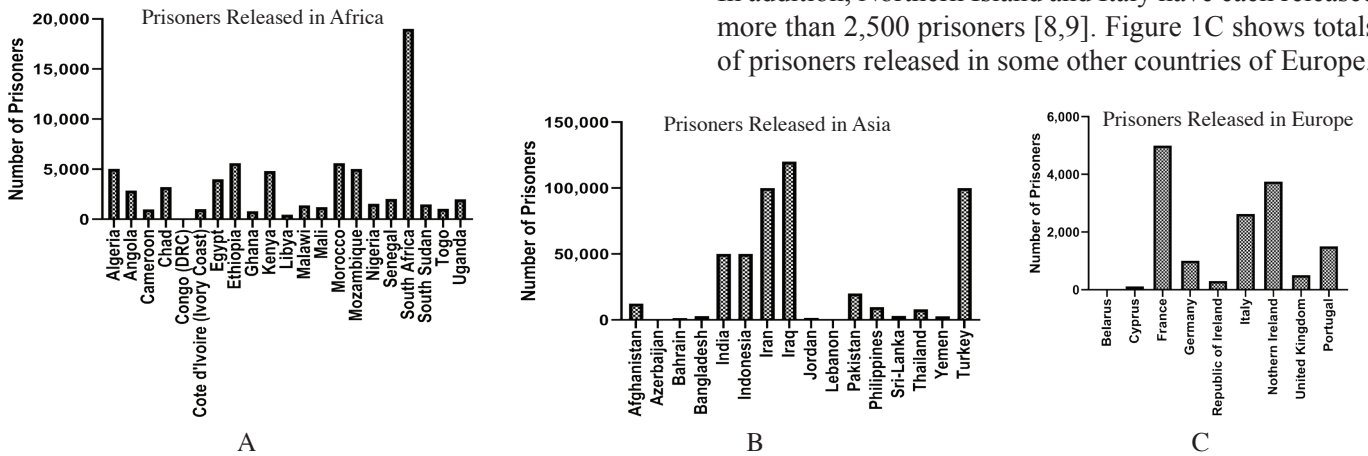

Figure 1. (A) The number of prisoners released in various African countries; (B) The number of prisoners released in various Asian countries; (C) The number of prisoners released in various European countries. [Figures were prepared by the authors based on data collected from more than 40 sources (not all listed in the References section), including websites, newspapers, articles, etc.]

Major Criteria for Prisoners' Release During COVID-19

Governments across the world have used different criteria for the early release of prisoners during the COVID-19 pandemic. Prisoners were released based on considerations that they were [10–12]:

- More than 50 (or in some venues 60) years of age;
- Involved in minor offenses;
- Pregnant women;
- Having less than six months left in the sentence;
- Showing good conduct during imprisonment;
- Having chronic diseases; and
- Having infants less than 3 years of age.

Besides other criteria for early release of prisoners (*see* **Figure 2**), the majority of the prisoners released were above 50 years of age.

Implications on Early Release of Prisoners

There are two factors that should be kept in mind. Firstly, the vulnerability of the virus is not a direct indication of prison release; it does not include the offense and serving time. The offense for which a prisoner is indicted is of vital importance, regardless of the age and health of the prisoner. Prisoners' criminal and medical histories should both be considered as a threat to other humans. Secondly, 2020 has shown us that the pandemic is unstable and the spread is discontinuous [1,13]. The problems that arise with risk management and control of COVID-19 spread include prison centers working with limited staff in case of positive reports, which is problematic in terms of handling the offenders. Decreasing the population of inmates from inside a prison means increasing their population in the outside world, and in turn, increasing the potentiality of crimes again [13].

The most difficult task for the policymakers is to draw the boundary line for the decision about prisoners' release. With the varying accuracy of different tests available for COVID-19, it is highly possible that some prisoners get released based on "false-positive" results. More importantly, the criminals released can return to their criminal behavior, which can be as problematic as (or more than) the COVID-19 itself.

In future pandemics, efficient planning must be created that should be far better than the general recommendations provided. Violent offenders, as reported previously, may continue offenses after release. Public safety is equally important and released prisoners can harm public safety in several ways. Consequences of post-release mortality should also be considered.

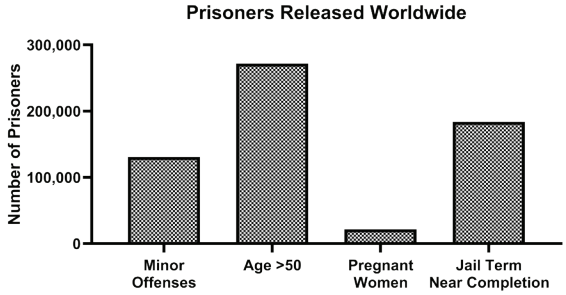

Figure 2. Criteria for releasing prisoners around the world during COVID-19 [Figure was prepared by the authors based on data collected from more than 40 sources (not all listed in the References section), including websites, newspapers, articles, etc.]

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Upcoming Events

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

The Association of Firearm and Tool Mark Examiners — 52nd Annual Training Seminar
(*https://afte.org/meetings/annual-seminars*)
Aug. 22–27, 2021; Hyatt Regency Miami
Miami, FL, 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

Mid-Atlantic Association of Forensic Scientists — Annual Meeting (*https://www.maafs.org/annual-meeting*)
Sept. 21–24, 2021; Kalahari Resort & Convention Center
Pocono Manor, PA, US

2021 International Conference on Forensic Nursing Science and Practice
(*https://www.forensicnurses.org/page/2020AnnualConference*)
Sept. 22–25, 2021; Hilton Orlando Lake Buena Vista
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; Virtual on-line meeting

California Association of Criminalists—Fall Seminar
(*cacnews.org/events/seminar/seminarcurrent.shtml*)
Oct. 17–23, 2021; BFS Jan Bashinski DNA Lab &
BFS Central Coast Labs
Scotts Valley, CA, US

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

TIAFT 2021: Annual Meeting of The International Association of Forensic Toxicologists
(*https://tiaft2021.co.za/general-information/*)
Jan. 29–Feb. 3, 2022; Cape Town Int. Convention Center
Cape Town, South Africa

American Academy of Forensic Sciences — 73rd Annual Meeting (*https://www.aafs.org/*)
Feb. 21–26, 2022; Seattle Convention Center
Seattle, WA, US

PITTCON Conference and Expo
(*https://pittcon.org/exposition/*)
March 5–9, 2022; Georgia World Congress Center
Atlanta, GA, US

ICDFF 2022: 16. International Conference on Digital Forensic and Forensics (*https://waset.org/digital-forensic-and-forensics-conference-in-march-2022-in-dubai*)
March 22–23, 2022; Dubai Int. Convention & Exhibition Centre
Dubai, UAE

American Society of Forensic Laborstory Directors—49th Annual Sysposium
(*https://www.ascld.org/ascld-annual-symposium/*)
April 24–28, 2022; Peppermill Resort
Reno, NV, US

Southern Association of Forensic Scientists — Annual Meeting (*https://safs1966.org/annual-meeting/*)
April 25–29, 2022; Chattanoogan Hotel,
Curio Collection by Hilton
Gulf Shores, AL, US

TIAFT 2022: Annual Meeting of The International Association of Forensic Toxicologists
(*http://www.tiaft.org/tiaft-annual-meeting.html*)
Sept. 5–8, 2022; Venue to be announced
Versailles, France

Advancing the Practice of Forensic Science in the United States — The Role of Forensic Science Standards[a]

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Forensic science based on sound practices and presented in an unbiased manner contributes to the administration of justice. In today's courtrooms, reliance on forensic evidence is increasing but if sound scientific principles are not applied, serious errors can occur. As we know, the best scientific practices are not static and they continue to evolve. For example, due to continued research, technology advancements, and changing applications, deoxyribonucleic acid (DNA) evidence is now generally accepted as reliably scientific. The same can be said of toxicological evidence, which is rooted in traditional science. However, other forensic disciplines have not necessarily adhered to the same level of scientific rigor. Therefore, it is of no surprise that the 2009 landmark National Research Council (NRC) Report *Strengthening Forensic Science: A Path Forward* identified numerous forensic science weaknesses in the United States, calling into question the validity of several methods/techniques and thus reemphasizing the need to strengthen the scientific process in forensic science [1].

The purpose of the NRC report was to assess how significant improvements could be made in forensic science since there were vague, unenforced, or no standard protocols governing forensic practice in a given discipline. Furthermore, the quality and variability of forensic practice was questionable due to "the absence of adequate training and continuing education, rigorous mandatory certification and accreditation programs, adherence to robust performance standards, and effective oversight." [1] Among their many recommendations, the NRC concluded,

> "*The bottom line is simple: In a number of forensic science disciplines, forensic science professionals have yet to establish either the validity of their approach or the accuracy of their conclusions, and the courts have been utterly ineffective in addressing this problem.*" [1]

Then, in 2016 the President's Council of Advisors on Science and Technology (PCAST) published a report titled *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods*, noting that there were still two major gaps in forensic science:

> "*(1) the need for clarity about the scientific standards for the validity and reliability of forensic methods and (2) the need to evaluate specific forensic methods to determine whether they have been scientifically established to be valid and reliable."* [2]

Their key recommendations include standardization and best practices for many of the forensic disciplines, particularly for pattern evidence such as toolmarks, shoe prints, and firearm analysis.

What Are Standards?

Standards facilitate trade, specify product design, establish safety protocols, and support a variety of services. Manufacturing processes and laboratory methods are based on standards. In forensic science, DNA, toxicology, and other disciplines have made use of standards for many years. A standard "sets objectively verifiable requirements, provides for common and repeated uses, rules or characteristics for activities or their results, and is aimed at the achievement of the optimum degree of order in a given context" [3]. Standards are designed to "reflect the level of agreement, expressed by interested parties, on what is required for a given activity, process, product or result" [3]. The outcomes include desirable characteristics of services and techniques such as quality, reliability, efficiency, rigor, and consistency among practitioners.

Another useful feature of standards is that they help organizations talk to each other in a common language. For example, the Combined DNA Index System (CODIS) is a searchable DNA database that can be searched nationwide. This was made possible because all data entry follow a standardized input format specified by the government, using

[a]The perspectives expressed here are solely those of the authors, not any of the institutions with which they are affiliated.

[b]J. Howe, P. King, G. E. Berg, and M. McKiel are chair, member, member, and consultant of the American Academy of Forensic Sciences' Standard Board (ASB); J. D. Ropero-Miller is chair of ASB Sustainability Presidential Ad-hoc Committee.

a set of numbers that represent a particular set of loci. [4] The DNA Identification Act of 1994 authorized the Federal Bureau of Investigation (FBI) to formally establish CODIS. [5] CODIS includes state databases and the national database known as the National DNA Index System (NDIS). Only laboratories representing federal, state, and local criminal justice agencies can submit profiles to NDIS [6].

Standards can be developed by a variety of groups, such as Standards Developing Organizations (SDOs), government agencies, and industry sectors. There are currently four SDOs that develop standards for forensic science:

- American Dental Association (ADA), which serves the forensic odontology community;
- ASTM International, which develops standards in several forensic disciplines;
- National Fire Protection Association (NFPA), involved with arson investigations; and
- Academy Standards Board (ASB), which is the only US-accredited SDO dedicated entirely to the creation and maintenance of forensic science standards.

The Changing Landscape for Forensic Evidence: The Role of Forensic Standards

> ***In his 1963 Letter from Birmingham Jail, Rev. Martin Luther King, Jr., reminded us that "Injustice anywhere is a threat to Justice everywhere.' Isn't that the point? We are not talking about good science merely for its own sake. We are talking about the need for good science in order to serve justice. And when justice is done, our society as a whole is better for it.***[c]
>
> **JUDGE HARRY EDWARDS**

The need for forensic science standardization was initially expressed when the federal courts changed the standard for admissibility of forensic evidence in *Daubert v. Merrell Dow Pharmaceuticals, Inc.* 509 U.S. 579 (1993). The *Daubert* ruling adopted the Federal Rule of Evidence 702 governing the admissibility of forensic evidence in lieu of the "general acceptance" test that was applied in 1923 through the Frye decision [7]. *Daubert* was quickly adopted by most state courts as well. Federal Rule of Evidence 702 states, "[i]f scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise" [8]. *Daubert* discusses a number of factors for a judge to consider in analyzing this rule. One of those factors is, for a particular scientific technique, the court should consider "the existence and maintenance of standards controlling the techniques' operation" [7]. While standards are not the only consideration in determining the validity of a particular scientific method, the US Supreme Court particularly used them as an example of what to look for in applying this rule of admissibility.

The Daubert ruling established judges as the "gatekeepers" of forensic science and expert witnesses, although judges typically do not have scientific background [7]. Without adequate science expertise to guide them, judges were still at the mercy of the state of forensic science as presented to them. The result was many judges were at a loss in determining what was good science. Something was needed to improve courtroom reliability on forensic science evidence.

Forensics Goes from TWGs to SWGs to OSACs

In the late 1980s, the FBI formed nine Technical Working Groups (TWGs) funded by the FBI to identify, discuss, and prioritize operational needs and requirements for a handful of forensic disciplines, including DNA Analysis Methods [9]. The TWGs created guidelines and recommendations (TWGDAM). TWGDAMs guidelines were published in the journal "Crime Laboratory Digest '' and were widely followed and implemented by the forensic science community, thus becoming de facto standards recognized by courts [9]. Due to funding challenges, the TWGs eventually disbanded.

The TWGs were later transitioned into 21 Scientific Working Groups (SWGs) in the 1990s to carry on the work, specifically to improve discipline practices and build standards rooted in accepted science. Many SWGs were funded by the US Department of Justice to increase the quality of the discipline that they represented. SWGs were not regulatory bodies and standards promulgated were left up to individual agencies to adopt and implement. SWG documents were published on the National Institute of Standards and Technology (NIST) website and are still available today at *https://www.nist.gov/oles/scientific-working-groups*.

The TWGs and SWGs were a strong start for improving quality within forensic disciplines. From a historical lens, we can see how they prepared the forensic and legal communities to voluntarily adopt and implement consensus-based documents. In response to the criticism detailed in the NRC Report, in 2014 the US Department of Justice (DOJ) and the NIST entered into a bilateral agreement to form two organizations. The first, administered by DOJ, was the National Commission on Forensic Science (NCFS), which would address forensic science policy issues. The

[c]This article appeared in the special MLK issue print edition with the headline "Letter From Birmingham Jail" and was published in the August 1963 Atlantic as "The Negro Is Your Brother". © 1963 Dr. Martin Luther King, Jr., © renewed 1991 Coretta Scott King. All works by MLK have been reprinted by arrangement with the Heirs to the Estate of Martin Luther King, Jr., care of Writers House as agent for the proprietor, New York, NY; *https://www.theatlantic.com/magazine/archive/2018/02/letter-from-a-birmingham-jail/552461/*.

charter for NCFS expired in 2017. The second, established by NIST, was the Organization of Scientific Area Committees for Forensic Science (OSACs), which were tasked to

> "*improve forensic practices by facilitating the development and promulgation of technically sound consensus-based documentary standards and guidelines for forensic science; promote standards and guidelines that are fit-for-purpose and based on sound scientific principles; promote the use of the OSACs standards and guidelines by accreditation and certification bodies, and establish and maintain working relationships with other similar organizations.*" [10]

The formation of the OSACs received input from a wide variety of stakeholders from the criminal justice, forensic science, research, and legal communities. Their 550-plus members have expertise in forensic science disciplines as well as scientific research, human factors, statistics, policy and law, and measurement sciences.

WHY VOLUNTARY?

The US SDO Standards system is private-sector based, not governmental. Standards produced by SDOs are voluntary until adopted into contracts or regulations subject to enforcement. The OSACs are not regulatory bodies and cannot enforce standards. Rather they promote the adoption and implementation of voluntary science-based forensic standards.

The Forensic Science Standards Board (FSSB) is the governing board of the OSAC structure, whose goal includes facilitating the promulgation of standards that will support the development of quality benchmarks and enhance consistency across the forensic science community [11]. The OSACs are made up of Scientific Area Committees (SACs) and 25 discipline-specific subcommittees who are responsible for drafting seed documents for one or more forensic disciplines and then sending them to SDOs to develop and publish via voluntary consensus standards procedures. Consensus reflects substantial agreement has been reached by a simple majority but does not necessarily indicate unanimity.

In the fall of 2019, NIST announced an update to the OSAC structure after receiving further stakeholder input. OSAC 2.0 was released, streamlining the processes to develop draft standards, allow public comment earlier, and have OSAC draft documents available on the OSAC Registry while under development at an SDO. Once the standards are published by an SDO, the FSSB oversees approving the placement of published standards onto the OSAC Registry. The Registry is available on the OSAC website, and of note, ANSI accreditation of a standard is not required by the OSAC Registry. The fact that draft standards can be found on the OSAC Registry along with published standards may cause public confusion.

Academy Standards Board

The American Academy of Forensic Sciences (AAFS) embraced the call for forensic science reform immediately after the release of the 2009 NRC report and continues to support its stated objectives "to promote education, foster research, improve practice, and encourage collaboration in the forensic sciences" [12,13]. Following the establishment of OSAC, in 2015 the AAFS formed the Academy Standards Board (ASB) as a forensic standards developer to support OSAC efforts. The AAFS is the largest private sector organization of more than 6,000 forensic professionals representing 11 sections: Anthropology, Criminalistics, Digital & Multimedia Sciences, Engineering & Applied Science, General, Jurisprudence, Odontology, Pathology/Biology, Psychiatry & Behavioral Science, Questioned Documents, and Toxicology [14] (**Figure 1**). The breadth of expertise and commitment of the AAFS membership made it a logical candidate to become an SDO dedicated to promoting rigor to uphold scientific integrity in which to elevate the standards of forensic science.

The ASB's ongoing mission is to safeguard justice and fairness through census-based documentary forensic science standards developed in accordance with the American National Standards Institute (ANSI) process. ANSI accredits US SDOs to be able to develop American National Standards (ANS). The accredited consensus process is open, fair, balanced, equitable, accessible, and responsive to stakeholder needs (due process). The process allows for critical thinking and implementation to be evaluated in a structured domain that includes public review and comment, which provides an opportunity for further scientific evaluation. All comments including those from the forensic and scientific communities, the legal community, academia, the public at large, and the standards body must be fully considered by the applicable Consensus Body that approves the content of an ASB document and whose vote demonstrates evidence of consensus before a document can become an ANS [15].

Figure 1. ASB consensus bodies.

ASB Documents

Currently, ASB publishes freely downloadable, consensus-based forensic science documents in the form of standards, guidelines, best practice recommendations, and technical reports on its website at https://www.asbstandardsboard.org/. Each ASB document type serves a specific purpose (**Figure 2**). *Standards* are written to establish objectively measurable requirements for a given topic or set of actions. A standard provides requirements that can be measured or assessed by one or more forms of conformity assessment procedures. *Guidelines* provide principles for streamlining certain processes or practices or act as implementation guides for a standard or series of standards. Guidelines are written when an issue, practice, situation, or condition does not call for the rigor of a standard, or to provide options for implementing parts or all of a given standard or series of standards. *Best practice recommendations* describe the optimal approach for an action or process. *Technical Reports* are explanatory, informative documents that provide scientific, technical, or operational information relevant to a standard, field of activity, or profession.

Standards developed through a consensus process further the applicability of the science, and for forensic standards this helps reduce the fragmentation of forensic science by uniting stakeholders that the NRC reports in more than half of its 13 recommendations [1,16]. All comments are considered; therefore, weaknesses and strengths should reasonably be expected to be exposed for consideration and scrutinized from all angles [17]. Additionally, forensic science standards enhance the value and usefulness of forensic science to the legal community [17].

Standards, Conformity Assessment, and Accreditation

Standards provide the foundation against which performance, reliability, and validity can be assessed. Such assessment, typically referred to as conformity assessment, can be done internally as part of management control or it can be done by an external third party. Third-party conformity assessment is the basis for accreditation that is a published status indicating that the accredited entity successfully demonstrated its conformance to written procedures and applicable standards.

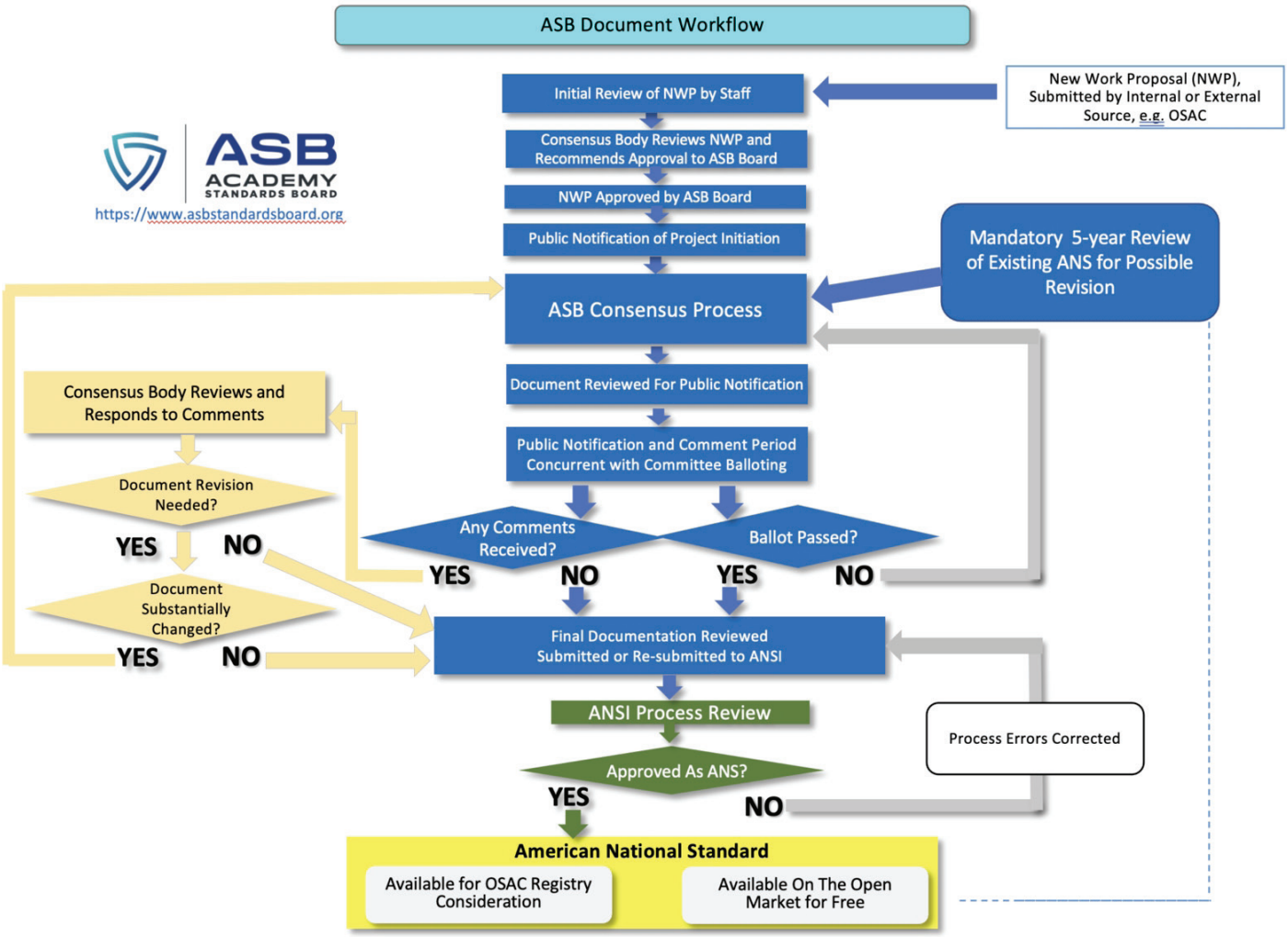

Figure 2. ASB document development flowchart.

Forensic laboratories incorporate standards in their written defined processes, practices, and methodologies. For example, the ISO standard 17025, *General requirements for the competence for testing and calibration laboratories*, is the basis for many state, federal, and private forensic laboratories [18]. Additional forensic standards — e.g., ASB or ASTM standards and best practice recommendations — may also be incorporated into written procedures in addition to the ISO standard. When third-party assessment of laboratory performance is required by statute, or is the choice of a private laboratory, certified assessors from an accrediting body do the conformity assessment. (The American National Accreditation Board, ANAB, and the American Association of Laboratory Accreditation, A2LA, are two examples of US-domiciled accrediting bodies.) Assessors review and document the laboratory's adherence to its written procedures, including assessing conformance to the standards incorporated by the procedures. An assessment outcome with no substantial lack of conformance results in a laboratory being given an accredited or reaccredited status. Conformity assessment for accreditation requires ongoing periodic inspections.

The conformity assessment accreditation process can strengthen confidence by law enforcement and the justice system that the forensic services provided are produced to an appropriate level of quality [19]. Accreditation of forensic laboratories began in earnest after a 1970s national critical examination of forensic science [20,21]. Sound scientific forensic standards currently being generated through combined work of the OSACs and SDOs, and adopted by laboratories as part of their accreditation, will advance the reliability of forensic science.

Conclusion

The criminal justice and legal systems benefit from sound science-based practices. Increased efforts to establish standards of practice that significantly improve and strengthen the science processes in forensic sciences answer the call for forensic reform and evidence-based representation in our legal system. Yet, forensic science continues to be scrutinized by stakeholders. Without the continued push to promulgate science-based forensic standards, the goals of maximizing equitable and inclusive opportunities, minimizing injustice, and reforming our criminal justice system in totality may go unrealized.

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NEW BOOKS AND BOOK REVIEWS

New Forensic Science Books

Analytical Pyrolysis Handbook, 3rd ed
K. D. Sam, T. P. Wampler, Eds
CRC Press: Boca Raton, FL, US; 2021

Analytical Techniques in Forensic Science
R. Wolstenholme, S. Jickells, S. Forbes, Eds
Wiley-Blackwell: Somerset, NJ, US; 2020

Battlefield Forensics — Using Criminalistics to Support Combat Operations
R. G. Meyer
CRC Press: Boca Raton, FL, US; 2021

Child Sexual Abuse: Forensic Issues in Evidence, Impact, and Management
I. Bryce, W. Petherick, Eds
Academic Press/Elsevier: Waltham, MA, US; 2020

Crime and Intelligence Analysis: An Integrated Real-Time Approach, 2nd ed
G. Grana, J. Windell
Routledge/CRC Press: Boca Raton, FL, US; 2021

Crime Scene Documentation: Preserving the Evidence & the Growing Role of 3D Laser Scanning
R. S. Galvin
CRC Press: Boca Raton, FL, US; 2021

Crime Scene Reconstruction Dynamics, Biomechanics, and Engineering Analysis
M. A. Knox
CRC Press: Boca Raton, FL, US; 2021

3D Forensic Mapping and Measurement in Crime Scene Reconstruction
E. Liscio
CRC Press: Boca Raton, FL, US; 2021

Digital Forensics Explained, 2nd ed
G. Gogolin, Ed
CRC Press: Boca Raton, FL, US; 2021

Emergency Characterization of Unknown Materials, 2nd ed
R. Houghton, W. Bennett
CRC Press: Boca Raton, FL, US; 2021

EMS in Crime Scene: Role of Medical Emergency Teams in Forensic Cases
A. M. Gomes
Academic Press/Elsevier: Waltham, MA, US; 2021

Estimation of Time since Death in Australian Conditions
J. Hayman
Academic Press/Elsevier: Waltham, MA, US; 2021

Fingerprints, Analysis and Understanding the Science, 2nd ed
M. R. Hawthorne, S. L. Plotkin, B.-A. Douglas
CRC Press: Boca Raton, FL, US; 2021

First Response to Bombing Incidents and Weapons of Mass Destruction
J. B. Crippin
CRC Press: Boca Raton, FL, US; 2021

Forensic and Clinical Forensic Autopsy — An Atlas and Handbook, 2nd ed
C. Pomara, V. Fineschi, Eds
CRC Press: Boca Raton, FL, US; 2021

Forensic Document Examination in the 21st Century
M. Angel, J. Seaman Kelly, Eds
CRC Press: Boca Raton, FL, US; 2021

Forensic DNA Analysis — Technological Development and Innovative Applications
E. Pilli, A. Berti, Eds
Apple Academic/CRC Press: Boca Raton, FL, US; 2021

Forensic Entomology Atlas and Pictorial Key
R.E. Williams, P. Jones, K. Bugajski
CRC Press: Boca Raton, FL, US; 2021

Forensic Neuropathology, 2nd ed
H. Whitwell, C. Milroy, D. du Plessis, Eds
CRC Press: Boca Raton, FL, US; 2021

Handbook of Forensic Statistics
D. L. Banks, K. Kafadar, D. H. Kaye, M. Tackett, Eds
Chapman & Hall/CRC Press: Boca Raton, FL, US; 2021

Injury Illustrated: How Medical Images Win Legal Cases
R. A. Gough
Routledge/CRC Press: Boca Raton, FL, US; 2021

Internet of Things, Threats, Landscape, and Countermeasures
S. Shiaeles, N. Kolokotronis, Eds
CRC Press: Boca Raton, FL, US; 2021

Mass Identifications: Statistical Methods in Forensic Genetics
D. Kling, T. Egeland, A. Tillmar, L. Prieto
Academic Press/Elsevier: Waltham, MA, US; 2021

Medicolegal Neuropathology — A Color Atlas, 2nd ed
E. W. Matshes
CRC Press: Boca Raton, FL, US; 2021

Pedigree Analysis in R
M. D. Vigeland
Academic Press/Elsevier: Waltham, MA, US; 2021

Practical Forensic Microscopy: A Laboratory Manual, 2nd ed
B. P. Wheeler
Wiley-Blackwell: Somerset, NJ, US; 2021

Professional Issues in Forensic Science
B. Gestring
Auerbach/CRC Press: Boca Raton, FL, US; 2021

Sexual Murder, Catathymic and Compulsive Homicides, 2nd ed
L. B. Schlesinger
CRC Press: Boca Raton, FL, US; 2021

Statistics and the Evaluation of Evidence for Forensic Scientists, 3rd ed
C. Aitken, F. Taroni, S. Bozza
Wiley-Blackwell: Somerset, NJ, US; 2020

Wastewater Analysis for Substance Abuse Monitoring and Policy Development
J. Prichard, W. Hall, P. Kirkbride, J. O'Brien
Routledge/CRC Press: Boca Raton, FL, US; 2020

Water-Related Death Investigation: Practical Methods and Forensic Applications, 2nd ed
K. L. Erskine, E. J. Armstrong
CRC Press: Boca Raton, FL, US; 2021

Wildlife Necropsy and Forensics
P. K. Sriraman
CRC Press: Boca Raton, FL, US; 2021

Book Review

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

A. Wayne Jones, Jørg G. Mørland, Ray H. Liu, Eds
CRC Press: Boca Raton, FL, US; 2020

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Toxicologists, drug recognition experts (DREs), traffic safety resource prosecutors, and other audiences will find Alcohol, Drugs, and Impaired Driving: Forensic Science and Law Enforcement Issues to be an important reference for their libraries. The editors, A.W. Jones, J.G. Mørland, and R.H. Liu, have many years of experience within the field of forensic toxicology and do an excellent job of capturing the current state of impaired driving research.

The book is divided into five main sections (*see* the "Contents" page of the book on the right): (I) History of DUI, (II) Other Historical Events of Interest, (III) Forensic Issues Involving Alcohol, (IV) Use of Non-Alcohol Drugs and Impaired Driving, and (V) Epidemiology, Enforcement, and Countermeasures. Readers will find the historical aspects educational as the authors detail the work of Professor Robert F. Borkenstein, the Grand Rapids Study, and the evolution of per se laws for both alcohol and other abused drugs. The foundation of these studies has served to advance the field to where it is today.

Traffic safety measures have improved over recent years with an emphasis on the detection of offenders under the influence of drugs other than alcohol by developing DRE programs and exploring oral fluid testing in such cases. Section V summarizes the literature with a focus on experimental and epidemiological studies while highlighting international trends of drug use among motor vehicle drivers. Furthermore, attorneys will find the chapters on common legal challenges and other forensic issues involving alcohol and drugs beneficial to prosecuting or defending such cases.

In conclusion, the chapters are well written and engaging. Practicing forensic toxicologists and legal professionals will find this book invaluable to serve as a reference for the most significant impaired driving research, when studying for certification exams, and preparing for expert witness testimony. I fully recommend this book for forensic practitioners of all experience levels.

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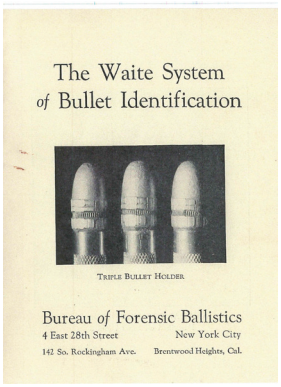
TEITELBAUM'S COLUMN ON FORENSIC SCIENCE — HISTORICAL PERSPECTIVE —

The Bureau of Forensic Ballistics



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> *What we need is a reliable method of determining from the bullets the type of weapon that fired them. I am trying to catalogue all firearms ever manufactured in this country which might today be used by criminals.* [1]

Thus began Charles E. Waite in his 1920 letter to every firearms manufacturer in the United States. The letter continued:

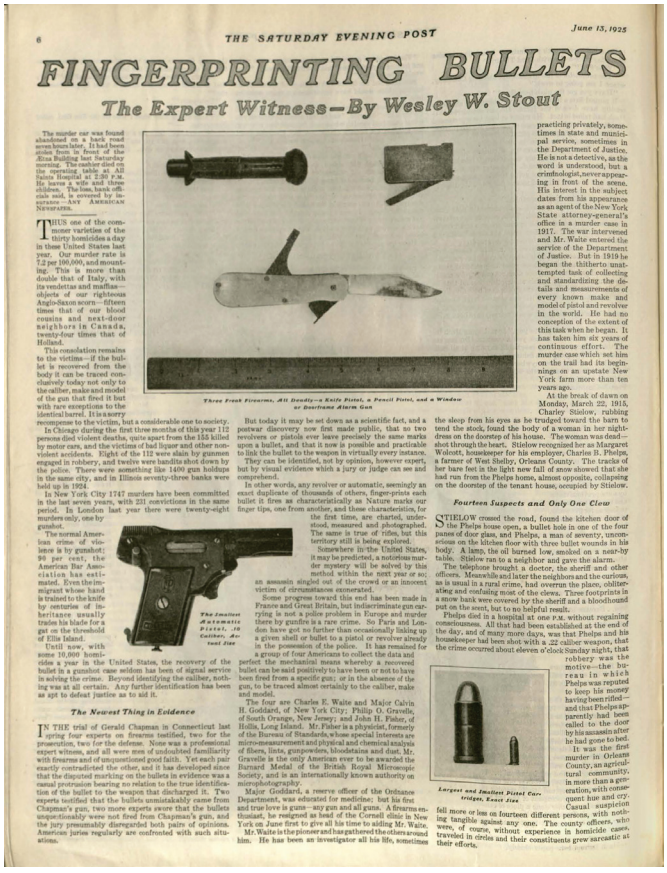
> *This means having precise data on the construction, date of manufacture, caliber, number, twist and proportions of the grooves and lands, as well as type of ammunition of as many guns as possible. I know that impressions of the grooves and lands can be found on bullets. The angle and direction of the rifling as well as the precise caliber can be determined from the bullet. If I had a register of all the characteristics of all types of guns, I would be in a position to determine the weapon used in a given homicide.*

Waite was not a firearms expert; he was an investigator in the New York State Office of the Attorney General. In 1917, a murder trial that was not even one of his cases caught his attention; the case would change the direction of his life, and it would change the direction of the field of firearms investigations.

In terms of historical significance, Calvin Goddard (1891–1955) is widely recognized as the most important pioneer in the field of forensic ballistics, and his work at the Scientific Crime Detection Laboratory in Chicago established the field on a solid scientific foundation. But the groundwork that led to Goddard's involvement in criminal investigations, and specifically firearms identification, began with Charles Waite (1865–1926), a man whose name is far less familiar even to many current forensic firearms practitioners.

The case that launched Waite into his obsession with firearms identification involved a farm worker in upstate New York named Charles Stielow, who was convicted in 1915 of fatally shooting his employer and his employer's housekeeper. Waite was horrified at the amateurishness of the courtroom testimony of the firearms "expert" and he asked Governor Charles Whitman if he could investigate the case on his own. Enlisting the help of a microscopist at Bausch & Lomb, Waite examined the bullets recovered in the murders as well as some bullets test-fired from a revolver that Stielow owned; he determined that the respective markings were completely different. This result, along with other evidence developed during an investigation by the deputy attorney general, led Gov. Whitman to commute Stielow's sentence and release him from prison in 1918.

Waite subsequently decided that to improve the field of firearms identification, he would need information about every gun manufactured in the United States. No one had ever compiled this kind of information before, and he soon found that the records of most gun companies were in a terrible state of disorder; he often needed to work for months at a given company to locate and organize the manufacturing specifications. Calvin Goddard would later write: "After three years of exhaustive travel and research, he (Waite)



6 THE SATURDAY EVENING POST June 13, 1925

FINGERPRINTING BULLETS

The Expert Witness—By Wesley W. Stout

The murder car was found abandoned on a back road seven hours later. It had been stolen from in front of the Atlas Building last Saturday morning. The owner died on the operating table at All Saints Hospital at 2:30 P.M. He leaves a wife and three children. The car, the police said, is covered by insurance.—ANY AMERICAN NEWSPAPER.

THUS one of the commoner varieties of the thirty homicides a day in these United States last year. Our murder rate is 7.2 per 100,000, and mounting. This is more than double that of Italy, with its vendettas and maffias—objects of our righteous Anglo-Saxon scorn—fifteen times that of our blood cousins and next-door neighbors in Canada, twenty-four times that of Holland.

This consolation remains to the victims—if the bullet is recovered from the body it can be traced conclusively today not only to the caliber, make and model of the gun that fired it but with rare exceptions to the identical barrel. It is a sorry recompense to the victim, but a considerable one to society.

In Chicago during the first three months of this year 112 persons died violent deaths, quite apart from the 155 killed by motor cars, and the victims of bad liquor and other non-violent accidents. Eight of the 112 were slain by gunmen engaged in robbery, and twelve were bandits shot down by the police. There were something like 1400 gun holdups in the same city, and in Illinois seventy-three banks were held up in 1924.

In New York City 1747 murders have been committed in the last seven years, with 221 convictions in the same period. In London last year there were twenty-eight murders only, one by gunshot.

The normal American crime of violence is by gunshot; 90 per cent, the American Bar Association has estimated. Even the immigrant whose hand is trained to the knife by centuries of inheritance usually trades his blade for a gat on the threshold of Ellis Island.

Until now, with some 10,000 homicides a year in the United States, the recovery of the bullet in a gunshot case seldom has been of signal service in solving the crime. Beyond identifying the caliber, nothing was at all certain. Any further identification has been as apt to defeat justice as to aid it.

Three Fatal Firearms, All Deadly—a Knife Pistol, a Pencil Pistol, and a Window or Doorframe Alarm Gun

The Smallest Automatic Pistol, .76 Caliber, Actual Size

The Newest Thing in Evidence

IN THE trial of Gerald Chapman in Connecticut last spring four experts on firearms testified, two for the prosecution, two for the defense. None was a professional expert witness, and all were men of undoubted familiarity with firearms and of unquestioned good faith. Yet each pair exactly contradicted the other, and it has developed since that the disputed marking on the bullets in evidence was a mental protrusion bearing no relation to the true identification of the bullet to the weapon that discharged it. Two experts testified that the bullets unmistakably came from Chapman's gun, two more experts swore that the bullets unquestionably were not fired from Chapman's gun, and the jury presumably disregarded both pairs of opinions. American juries regularly are confronted with such situations.

But today it may be set down as a scientific fact, and a postwar discovery now first made public, that no two revolvers or pistols ever leave precisely the same marks upon a bullet, and that it now is possible and practicable to link the bullet to the weapon in virtually every instance.

They can be identified, not by opinion, however expert, but by visual evidence which a jury or judge can see and comprehend.

In other words, any revolver or automatic, seemingly an exact duplicate of thousands of others, finger-prints each bullet it fires as characteristically as Nature marks our finger tips, one from another, and these characteristics, for the first time, are charted, understood, measured and photographed. The same is true of rifles, but this territory still is being explored.

Somewhere in the United States, it may be predicted, a notorious murder mystery will be solved by this method within the next year or so; an assassin singled out of the crowd or an innocent victim of circumstances exonerated.

Some progress toward this end has been made in France and Great Britain, but indiscriminate gun carrying is not a police problem in Europe and murder there by gunfire is a rare crime. So Paris and London have got no further than occasionally linking up a given shell or bullet to a pistol or revolver already in the possession of the police. It has remained for a group of four Americans to collect the data and perfect the mechanical means whereby a recovered bullet can be said positively to have been or not to have been fired from a specific gun; or in the absence of the gun, to be traced almost certainly to the caliber, make and model.

The four are Charles E. Waite and Major Calvin H. Goddard, of New York City; Philip O. Gravelle, of South Orange, New Jersey; and John H. Fisher, of Hollis, Long Island. Mr. Fisher is a physicist, formerly of the Bureau of Standards, whose special interests are micro-measurement and physical and chemical analysis of fibers, lints, gunpowders, bloodstains and dust. Mr. Gravelle is the only American ever to be awarded the Barnard Medal of the British Royal Microscopic Society, and is an internationally known authority on microphotography.

Major Goddard, a reserve officer of the Ordnance Department, was educated for medicine; but his first and true love is guns—any gun and all guns. A firearms enthusiast, he resigned as head of the Cornell clinic in New York on June first to give all his time to aiding Mr. Waite.

Mr. Waite is the pioneer and has gathered the others around him. He has been an investigator all his life, sometimes practicing privately, sometimes in state and municipal service, sometimes in the Department of Justice. He is not a detective, as the word is understood, but a criminologist, never appearing in front of the scene. His interest in the subject dates from his appearance as an agent of the New York State attorney-general's office in a murder case in 1917. The war intervened and Mr. Waite entered the service of the Department of Justice. But in 1919 he began the thitherto unattempted task of collecting and standardizing the details and measurements of every known make and model of pistol and revolver in the world. He had no conception of the extent of this task when he began. It has taken him six years of continuous effort. The murder case which set him on the trail had its beginnings on an upstate New York farm more than ten years ago.

At the break of dawn on Monday, March 22, 1915, Charley Stielow, rubbing the sleep from his eyes as he trudged toward the barn to tend the stock, found the body of a woman in her nightdress on the doorstep of his house. The woman was dead—shot through the heart. Stielow recognized her as Margaret Wolcott, housekeeper for his employer, Charles R. Phelps, a farmer of West Shelby, Orleans County. The tracks of her bare feet in the light new fall of snow showed that she had run from the Phelps home, almost opposite, collapsing on the doorstep of the tenant house, occupied by Stielow.

Fourteen Suspects and Only One Clew

STIELOW crossed the road, found the kitchen door of the Phelps house open, a bullet hole in one of the four panes of door glass, and Phelps, a man of seventy, unconscious on the kitchen floor with three bullet wounds in his body. A lamp, the oil burned low, smoked on a near-by table. Stielow ran to a neighbor and gave the alarm.

The telephone brought a doctor, the sheriff and other officers. Meanwhile and later the neighbors and the curious, as is usual in a rural crime, had overrun the place, obliterating and confusing most of the clews. Three footprints in a snow bank were covered by the sheriff and a bloodhound put on the scent, but to no helpful result.

Phelps died in a hospital at one P.M. without regaining consciousness. All that had been established at the end of the day, and of many more days, was that Phelps and his housekeeper had been shot with a .22 caliber weapon, that the crime occured about eleven o'clock Sunday night, that robbery was the motive—the bureau in which Phelps was reputed to keep his money having been rifled—and that Phelps apparently had been called to the door by his assassin after he had gone to bed.

Largest and Smallest Pistol Cartridges, Exact Size

It was the first murder in Orleans County, an agricultural community, in more than a generation, with consequent hue and cry. Casual suspicion fell more or less on fourteen different persons, with nothing tangible against any one. The county officers, who were, of course, without experience in homicide cases, traveled in circles and their constituents grew sarcastic at their efforts.

Figure 1. *Saturday Evening Post*; June 13, 1925 [4] (Public domain).

had detailed technical data on every firearm from every major and minor gun maker in the US. At the same time, he commenced a collection of sample unfired bullets, empty primed shells, loaded cartridges, and specimen firearms, in every possible make, type, caliber, and variety." [2]

Of course, there was the occasional setback. When Waite was visiting the New York City police headquarters in 1922, he was shown thousands of firearms that had been confiscated over the previous year. He realized with a shock that most of them were foreign-made and were completely unknown to him. Furthering his distress, he was told that in 1922 alone, 559,000 guns had arrived through the port of New York [1][a]. Realizing that all of his work collecting data on US guns would be undermined by this infusion of foreign guns, he set out for Europe to start again.

In June 1925, the *Saturday Evening Post* [4] published two extensive articles about the new science of bullet and firearm identification (**Figure 1**). It was the first published account of the work Waite had been doing, along with the first descriptions of the newly designed analytical instruments (the helixometer and the comparison microscope) that were being used in this new field. From the article:

> *Mr. Waite returned from Europe late in 1923 with trunkloads of shop standards, blueprints and specimens of foreign small arms, and began the tedious task of indexing, codifying and reducing European millimeter measurements to thousandths of an inch. He now had the precise dimensions and the family characteristics of every make and model of gun which might normally be expected to turn up in an American homicide. He also learned that there were manufacturers, particularly in Spain, who would stamp the name of any buyer onto stock revolver barrels, making precise identification particularly difficult.* [4]

Waite realized that he now needed new types of sophisticated instruments that would reveal the minute differences between ammunition and firearms; he soon found two men who became nearly as obsessed as Waite in this new field. John Fisher was a physicist formerly with the Bureau of Standards, and Philip Gravelle was a highly respected microscopist and microphotographer. Fisher developed the *helixometer* (**Figure 2**), which was an adaption of an optical instrument called the cystoscope. With the helixometer, it was now possible to visually examine the interior surfaces of the bore of a firearm as well as to measure the pitch of the rifling. The comparison microscope, an assembly of two compound microscopes fitted with a comparison eyepiece, was already used in other fields, but Gravelle was the first to

[a]Just two years later, in 1924, Goddard reported that over 700,000 cheap revolvers poured into the United States from Spain alone [3].

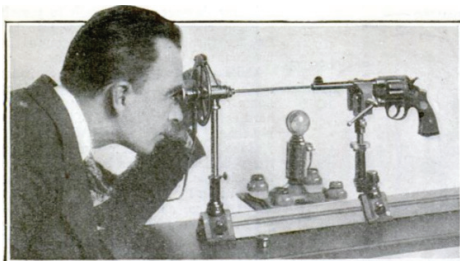


Figure 2. John Fisher using a helixometer (Goddard business pamphlet) (public domain).

adapt it to use in the identification of firearms. The utility of these instruments was elucidated by Goddard:

> *Hence, every pistol barrel, even when fresh from the factory (and much more so after undergoing wear and tear) contains minute irregularities which are peculiar to it alone, and which will never be reproduced in any other. These irregularities leave their marks, the same ones each time, in the form of fine and coarse linear striations parallel to the deep incisures cut by the groove edges, on every bullet fired from this barrel, and they constitute, to all intents and purposes, a fingerprint of that particular barrel.* [5]

In a 1933 letter, Gravelle wrote:

> *This (the comparison microscope) was shown for the first time to Mr. Wesley W. Stout, associate editor of the Saturday Evening Post, April 2, 1925, while he and Mr. Waite were visiting my laboratory in South Orange. Waite did not grasp the significance of the microscope assembly until several days later. Then followed the Saturday Evening Post article of June, 1925, which you know about. This was the first published description of the use of the comparison microscope in matching striae on bullets, etc.* [6]

In 1925, Waite decided to form a business with Fisher, Gravelle, and Calvin Goddard, whom Waite had become acquainted with during his research on firearms. Goddard had developed a fascination with firearms as a teenager, and he served in the Army's Ordnance Corp for a brief time before finding employment at the Johns Hopkins Hospital. But his interest in guns eventually led to a meeting with Waite in 1925, and he immediately decided to join the new ballistics group. They called the new organization the *Bureau of Forensic Ballistics*. In Goddard's words,

> *The Bureau is an organization established for the avowed purpose of banishing "opinion" from any legal question bearing upon small arms, ammunition, and their components. It aims to supplant opinion with facts, and where it is unable to do this, it much prefers to withdraw altogether rather than venture an opinion no matter how certain it may be that this is correct.* [5]

The Bureau was only marginally successful, largely because the field of scientific firearms identification was still in its infancy. When Waite died of a heart attack on November 14, 1926, Goddard became the undisputed leader of the ballistics organization, and one of his key undertakings was to try to persuade the courts and police that forensic ballistics was now an exact science. Soon after, Goddard became involved with the Sacco and Vanzetti case, which demonstrated definitively the soundness of the new science of forensic ballistics.

In his book about the history and science of firearms identification (published posthumously), Goddard was quite candid about his relationship with Waite:

> *I was in constant conflict with Waite over the amount of information to be released with regard to instruments and methods. He was all for publicity—of the kind that would bring in business, but violently opposed to the dissemination of any data which might enable competitors to duplicate our work in any degree whatsoever. He disapproved heartily of my contributions to scientific journals on the subject of our studies, and would agree to their publication only if and when I would incorporate sufficient commendatory remarks concerning his personality, to satisfy his by no means feeble ego.*
>
> *Yet, to my certain knowledge, he never once examined an evidence bullet or shell from the time of my joining him, in the Spring of 1925, until his death in November, 1926, relying upon me to do this in every instance.*
>
> *And, in retrospect, Waite did furnish the idea. Without his promotional ability to inflame my enthusiasm, I should never have resigned a lucrative position, as I did, in order to join him, or paid him the sum I did for a half interest in a pig-in-a-poke. Neither would Gravelle or Fisher have made their fundamental contributions to the science of arms identification.* [2]

Author's note: I was puzzled that I never saw a single photograph of Waite in my research, and then I found an extensive newspaper obituary of him with the headline: "Waite, man of mystery to the end, never would pose for a photograph." (*Fremont Messenger* (Fremont, OH), February 18, 1927).

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COMMENTARY

Jurisprudence and Ethical Dilemmas on the Autonomy of Illicit Substance Users — A Greek Perspective[a]

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Substance, Individual, and Society as Determinants of Substance Abuse

Substance abusers are often treated with hostility and viewed as individuals living parasitically at the expense of others rather than as people in need of help [1]. Society seems reluctant to forgive drug addicts for their choices and their divergence in general, and this attitude may even continue after their detoxification. Indeed, social representations of addicts are often characterized by fears, prejudice, stereotypes, and systemic racism. On the contrary, consumer of legal substances such as alcohol, tobacco, energy drinks, and caffeine generally are socially acceptable and do not get stigmatized, with the exception of some borderline alcohol-dependent individuals [2].

Therefore, substance abuse does not occur in a neutral and indifferent environment, but in a society having a series of reactions to the phenomenon. These reactions are concentrated on a dynamic that confronts substance abusers with the rest of society and greatly influences consumer behavior itself and the phenomenon of substance abuse in general. Therefore, in addition to *substance* and the *individual*, another determinant of the problem is *society* — in particular, the way society perceives the phenomenon of substance abuse. The social perception of drug use is negative and certainly disproportionate to the real consequences of the phenomenon. This behavior is partly based on reasonable justifications, linked to the serious social implications of uncontrolled substance abuse [3].

It should first be noted that every social phenomenon has symbolic importance and corresponds to the values defined by the political-philosophical system within which individuals and societies develop. Therefore, the recognition of drug abuse and dependence as a social problem is very much linked to the cultural and social context within which the phenomenon develops, but also provides for the social reaction it entails. Substance abuse and addiction, in addition to being a pharmacological phenomenon, is also an antisocial and self-punishing behavior. The social dimension of the phenomenon becomes apparent in four main manifestations of social dysfunction:

- The harmful effects of substance-use disorder on the users' physical and mental-emotional health — and thus, to an extent on public health [4];

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[a]The present research study pertains to the first and second authors' doctoral dissertations/theses with Documentation Codes 7/26-03-2016 and 13/16-07-2019, respectively.

- Its detrimental effects on their families [5];
- The users' social exclusion and exclusion from the production process [6]; and
- The association of drug use with delinquent and violent behavior [7].

Drugs and Drug Laws

According to the World Health Organization, *drugs* are defined as any substance that, when introduced into a living organism, can alter one or more functions, of the organism's physiology or psychology. *Psychotropic drugs* are defined as any substance that changes an organism's brain function and results in alterations in perception, mood, consciousness, cognition, or behavior. They are toxic, natural, or chemical substances. *Substance abuse* refers to the harmful or hazardous use of psychoactive substances, including alcohol and illicit drugs. Psychoactive substance use can lead to dependence syndrome — a cluster of behavioral, cognitive, and physiological phenomena that develop after repeated substance use and that typically include a strong desire to take the drug, difficulties in controlling its use, persisting in its use despite harmful consequences, a higher priority given to drug use than to other activities and obligations, increased tolerance, and sometimes a physical withdrawal state [8].

Drug laws in Europe operate within the general context provided by the international system of control based on three United Nations Conventions [9]. This system establishes a framework for the control of production, trade, and possession of psychotropic substances. The conventions compel each country to face unauthorized supply as a criminal offense. The same applies to the possession of drugs for personal use, but is subject to the constitutional principles and basic concepts of its legal system. This clause has not been uniformly interpreted by European countries, which is reflected in different legal approaches [9].

According to Law 4139/2013, article 1, paragraph 1 of the Greek Penal Code, as narcotic drugs, within the meaning of this law, are termed substances with different chemical structures and different activities in the central nervous system and with common properties of changing the user's emotional state (mood) and causing dependency of a different nature, mental and/or physical, and of various degrees, as well as the relief of chronic patients from the symptoms of a particular disease for which they are considered medically necessary [10]. The *Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5)* recognizes substance-related disorders resulting from the use of 10 separate classes of drugs: alcohol; caffeine; cannabis; hallucinogens (including phencyclidine, arylcyclohexylamines, and others, such as LSD); inhalants; opioids; sedatives, hypnotics, or anxiolytics; stimulants (including amphetamine-type substances, cocaine, and other stimulants); tobacco; and other or unknown substances.

Two groups of substance-related disorders are defined: *substance-use disorders* and *substance-induced disorders*. The *DSM-5* criteria for substance-use disorders are defined as follows:

- Hazardous use: use of the substance in ways that are dangerous to self and/or others, i.e., overdoses, driving while under the influence, or blacking out;
- Continuation of the substance use despite social or interpersonal problems related to use;
- Neglected major roles to use: failing to meet one's responsibilities at work, school, or home because of the substance use;
- Experiencing withdrawal symptoms;
- Having built up a tolerance to the substance so that getting the same effect requires using larger amounts;
- Using larger amounts/longer;
- One or more repeated attempts to control use or quit;
- Much time spent using the substance;
- Physical or psychological problems related to use;
- Activities given up to use: cessation or withdrawal from activities one once enjoyed in order to use the substance; and
- Having experienced craving for the substance.

The diagnosis is made when the user meets two or more of these criteria within a 12-month period. If one meets two to three criteria, a *mild* substance-use disorder is diagnosed, four to five is considered *moderate*, and six or more criteria is diagnosed as *severe* substance-use disorder [11].

Issues Related to Substance-Use Disorder

With regard to delinquency, issues related to substance-use disorder represent a serious and ever-increasing problem as faced by both the international and the Greek legal system. Defendants, either addicted or intoxicated or arrested for drug-related offenses, constitute a population sample that has documented the highest rates of delinquency worldwide compared to any other population group concerning the criminal system. It is estimated that the likelihood of a user of illegal psychoactive substances being arrested for theft or robbery is 16 times greater than the average individual [12]. Evidence-based research studies have indicated that substance abuse has a much more significant role in increasing the likelihood of committing a violent act. Substance misuse raised the rate of violence in both patients diagnosed with a mental disorder (43.6%) and healthy individuals (35%) but did so disproportionately in the patient group, indicating the role of substance abuse as a mediating factor between mental illness and violence [7].

It should also be noted that individuals suffering from drug-abuse disorder as a population sample differ signifi-

cantly with respect to the type, frequency, and severity of the offenses they commit. Their profile can be summarized in the following four points:

- Addicts commit far more illegal acts during periods of dependency than periods of abstinence;
- Addicts, who start criminal activity and substance use early, tend to commit a disproportionately high rate of crimes;
- The racial or minority context plays an important role in the type of illegal acts that they enact; and
- Delinquency appears to be inversely proportional to age indicating the offending course of users. Furthermore, treatment rates tend to differentiate with reference to delinquency: younger users tend to engage in less violent offenses (drug possession and trafficking) with shorter sentences and are more likely to have a better prognosis with reference to treatment; while older users often associate with more violent crimes with increased jail time, resulting in their being marginalized for a longer period of time and reduced survival rate [12].

Criminal Responsibility

The concept of criminal responsibility as a prerequisite for punishment is recognized by all European legislations. Individuals lacking criminal responsibility for committed offenses are, thus, exempt from punishment and are usually admitted to a treatment facility (or given acquittal) rather than being subject to punishment. Some grading of criminal responsibility is recognized by the majority, but not totality, of the European countries, which means that an individual is not only seen as either *fully responsible* or *completely irresponsible* for their actions but can be of *reduced responsibility*. Such diminished responsibility, in the countries where it is legally recognized, can then result in a more lenient punishment, such as a shorter sentence of imprisonment [13,14].

Some degree of diminished responsibility is the sole requirement by the majority of European countries for admission into the forensic-psychiatric system; while on the contrary, individuals legally having full responsibility for committed offenses are subject to punishment, even if, at the time of their acts, they were suffering from a mental disorder. In other countries such as the UK, however, forensic-psychiatric care is accessed independently of criminal responsibility, while judgment is determined only by the mental condition at the time of assessment. Several exclusion criteria are provided by a number of national laws within Europe for detention in psychiatric and forensic-psychiatric facilities, such as personality disorders, substance-use disorders, or sexual deviancy, which may be welcome from a civil liberty perspective, but also meaning that some diagnostic groups will be excluded from medical provisions. Forensic psychiatry operates within the legal and societal context of a country and is therefore subject to the wider influences and trends of that society, which are man-made and normative, and as such can be changed at any time [15,16].

Regarding Greek jurisprudence, in accordance with Article 34 of the Greek Penal Code: "The act is not imputed to the perpetrator if, when committing it, due to morbid disturbance of mental functions or disturbance of consciousness, the individual did not have the capacity to perceive the injustice of their action or act in accordance with their perception of this injustice" (capability to appreciate the legal wrongfulness of the act and/or ability to act accordingly and conform behavior to the law) [17]. Furthermore, in accordance with Article 36 of the Greek Penal Code [17]:

1. If, as a result of any of the mental conditions referred to in Article 34, even if not completely abolished, the capacity for criminal responsibility required under that Article has been significantly reduced, a reduced penalty is imposed (Article 83).
2. The provision of the preceding paragraph shall not apply in the case of alcohol intoxication. [17]

The wording of the provision clarifies that the legislators perceived the act to be attributed to the perpetrator as the rule, while the incapacity for criminal responsibility is exceptionally regulated by a mixed biological-psychological method. The capacity for criminal responsibility, however, is not substantiated. On the contrary, the court should be convinced as to whether the offender is capable or incapable of being charged and in case of doubt the principle of "in dubio pro reo" should apply, that is to say, "the balance in favor of the accused". In particular, two types of criteria are used to assess the offender's impotence:

- Biological (the morbid disturbance of mental functions or disturbance of consciousness); and
- Psychological (the offender's inability to either assess injustice or comply with his assessment regarding injustice).

In this case, since the human health condition is causally linked to his inability to comply with the requirements of the legal system, the exclusion (Article 34 of Greek Penal Code) or reduction (Article 36 of Greek Penal Code) of the criminal responsibility capacity is recognized. The biological criteria should, thus, be linked with those of the psychological level. In any case, however, the time for committing the act is the one used to assess the condition of the offender [17].

Jurisprudence and Ethical Dilemmas on the Autonomy of Illicit Substance Users

Autonomy could be defined as the situation in which one has the opportunity to freely dispose oneself, govern oneself, and live in accordance with one's basic desires or values [18]. Within this context, recent observations

on the phenomenon of substance dependence emphasize additional parameters such as those of individual choice, namely the individual's own choice of the substance use, which results in abuse and dependence [19]. This explanation goes far beyond the point of view of dependency as a disorder of impulse, which is not subject to conscious control. This view is contradicted, however, since the concept of autonomy, which is largely identical to the principle of self-determination, presupposes that any choice of individual has to be made within a "grid of freedoms", that sadly a substance addict cannot have. In particular, what could be said is that a substance addict has a disturbed emotional function, with insurmountable problems in human communication and relationship, and with unfulfilled emotional needs, most often since childhood. Unfulfilled needs, deadlocks, and internal conflicts cause pain and anxiety to the individual. Therefore, the substance abuse is enacted as a form of failed "self-treatment". In this form of "self-treatment", the substance of choice is usually one of the so-called "hard" drugs, such as heroin, which on a mental level, bring the desired results. In addition, a lack of self-trust, self-respect, and confidence toward both oneself and others characterizes the substance abusers' approach toward social reality [20].

Frequently, public opinion erroneously believes that individuals with substance abuse achieve an "easily acquired happiness", but the truth is that they do not manage to enjoy life whatsoever. They are unable to enjoy the simple, everyday joys of life, as all of their existence is consumed by the constant pursuit of the next dose, which should be able to restore, at least temporarily, their fragile inner balance and unstable affect [12]. Therefore, it could be said that the concept of autonomy for substance users does not exist to an extent that these individuals could be able to dominate their lives or make choices in the light of their freedom, and thus, their autonomy.

The authors of the present article aim to deal with the timeless moral dilemmas on the existence of autonomy in illicit substance abuse (excluding legal addictive substances, such as alcohol, caffeine, and nicotine, as well as other addictions, including pathological gambling and internet addiction). Special reference is made to the concept of illicit drug abusers' autonomy and to the moral dilemmas arising around the issue of addiction.

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