Professional Review and Historical Perspective[a]

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Forensic Science Review's Professional Review & Historical Perspective section highlights contemporary issues and events in the profession of forensic science. To make contributions or to recommend books for review or events for listing, please contact Ray Liu (rayliu@uab.edu).

[a]The views expressed are those of the authors and do not necessarily reflect the view, the position, or the policy of *Forensic Science Review* or members of its editorial board.

FORENSIC SCIENCE AROUND THE WORLD

Upcoming Events

The 10th International Conference on Behavioral Addictions
(*https://icba.issba.hu/*)

July 7–9, 2025; La Cité Nantes Congress Centre
Nantes, France

ADLM (Association for Diagnostics & Laboratory Medicine) 2025
(*https://meeting.myadlm.org/*)

July 27–31, 2025; McCormick Place Convention Center
Chicago, IL, US

IACP Impaired Driving and Traffic Safety Conference
(*https://www.theiacp.org/IDTSconference*)

Aug. 4–6, 2025; McCormick Place West Convention Center
Chicago, IL, US

APA Annual Convention 2025 — American Psychological Association
(*https://convention.apa.org/*)

Aug. 7–9, 2025; Colorado Convention Center
Denver, CO, US

International Association for Identification — 109th Educational Conference
(*https://cvent.me//41Z31w*)

Aug. 10–16, 2025; Rosen Shingle Creek Resort
Orlando, FL, US

ACS Fall National Meeting & Exposition 2025
(*https://www.acs.org/meeting/acs-meetings.html*)

Aug. 17–21, 2025; Walter E Washington Convention Center
Washington, DC, US

American Society of Questioned Document Examiners 83rd Annual Conference
(*https://asqde.org*)

Aug. 18–20, 2025; Harrah's Las Vegas
Las Vegas, NV, US

International Conference on Forensic Nursing Science & Practice
(*https://www.forensicnurses.org/page/FutureConferences/*)

Aug. 19–20, 2025; CHI Health Center Omaha
Omaha, NE, US

Midwestern Association of Forensic Scientists — 2025 Annual Meeting
(*https://mafs.net/page-18404*)

Aug. 24–29, 2025; Renaissance Columbus Downtown Hotel
Columbus, OH, US

American Society of Trace Evidence Examiners — 2025 Annual Conference
(*http://www.asteetrace.org/events*)

Aug. 24–29, 2025; Renaissance Columbus Downtown Hotel
Columbus, OH, US

18th Annual Alcohol Law & Policy Conference
(*https://www.centerforalcoholpolicy.org/law/*)

Aug. 25–27, 2025; Hyatt Centric Chicago Magnificent Mile
Chicago, IL, US

Cape Cod Symposium on Addictive Disorders
(*https://www.hmpglobalevents.com/symposia-addictive-disorders*)

Sept. 4–7, 2025; Cape Cod Village at the Emerald Resort
Hyannis, MA, US

Microneedle & Transdermal Delivery Forum 2025
(*https://www.pharmaedresources.com/events/*)

Sept. 9–10, 2025; The Racquet Club of Philadelphia
Philadelphia, PA, US

59th Congress of the European Societies of Toxicology
(*https://www.eurotox2025.com/*)

Sept. 14–17, 2025; Megaron Athens International Conference Centre
Athens, Greece

International Society of Substance Use Professional Regional Conference on Drug Prevention, Treatment and Care
(*https://www.issup.net/about-issup/workshops/bali-2025*)

Sept. 17–19, 2025; Discovery Kartika Plaza Hotel
Bali, Indonesia

23rd International Congress of Therapeutic Drug Monitoring & Clinical Toxicology
(*https://www.iatdmct2025.org/*)

Sept. 21–24, 2025; Grand Copthorne Waterfront Hotel
Singapore, Singapore

Robert F. Borkenstein Course on "The Effects of Drugs on Human Performance and Behavior"
(*https://bcahs.indiana.edu/drugcourse/index.html*)

Sept. 22–26, 2025; Science History Institute & Virtual
Philadelphia, PA, US

East Coast Symposium on Addictive Disorders
(*https://hmpglobalevents.com/symposia-addictive-disorders*)

Oct. 3–5, 2025; Sawgrass Marriott Golf Resort & Spa
West Palm Beach, FL, US

SCIX 2025 (Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies)
(*https://scixconference.org*)

Oct. 5–10, 2025; Northern Kentucky Convention Center
Covington, KY, US

NAADAC Annual Conference (The Association for Addiction Professionals)
(*https://www.naadac.org/annualconference*)

Oct. 11–13, 2025; Hyatt Regency Bellevue
Seattle, WA, US

14th World Gene Convention 2025 (European Branch)
(*https://www.clocate.com/world-gene-convention-wgc/43385/*)

Oct. 15–17, 2025; Crowne Plaza Nice — Grand Arenas
Nice, France

ICT2025 (The 17th International Congress of Toxicology)
(*https://www.ict2025.com/en/web/index/*)

Oct. 15–18, 2025; Beijing Guoce International Conference and Exhibition Center
Beijing, China

Canadian Society of Addiction Medicine (CSAM-SMCA) Annual Meeting and Scientific Conference
(*https://csam-smca.org/events-training/events-conferences/*)

Oct. 16–18, 2025; Le Centre Sheraton Montreal
Montreal, QC, Canada

National Association of Medical Examiners
(*https://name.memberclicks.net/annual-meetings*)

Oct. 17–21, 2025; Louisville Marriott Downtown
Louisville, KY, US

International Association of Chiefs of Police 2025
(*https://www.theiacpconference.org/*)

Oct. 18–21, 2025; Colorado Convention Center
Denver, CO, US

Southwestern Association of Forensic Scientists — 47th Annual Conference (*http://swafs.us/*)

Oct. 19–23, 2025; Courtyard by Marriott
South Padre Island, TX, US

GAB 2025 (6th Edition of Global Conference on Addiction Medicine, Behavioral Health and Psychiatry)
(*https://addiction-behavioral-conferences.magnusgroup.org*)

Oct. 20–22, 2025; Hilton Garden Inn Lake Buena Vista/Orlando
Orlando, FL, US

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

Oct. 20–24, 2025; Lancaster Marriott at Penn Square
Lancaster, PA, US

3rd Annual Medical Cannabis Conference
(*https://store.cannabisclinicians.org/scc-conference-2025/*)

Oct. 24–25, 2025; Auraria Campus
Denver, CO, US

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

Oct. 26–31, 2025; Oregon Convention Center
Portland, OR, US

ISHI 36: International Symposium on Human Identification
(*https://www.ishinews.com/attend/*)

Nov. 3–6, 2025; Palm Beach Convention Center
Palm Beach, FL, US

AMERSA Conference (Association for Multidisciplinary Education and Research in Substance Use and Addiction)
(*https://amersa.org/*)

Nov. 13–15, 2025; Hyatt Regency at the Oregon Convention Center
Portland, OR, US

Global Congress on Forensic Science and Research (Forensic Research-2025)
(*https://forensic.theiconicmeetings.com/*)

Nov. 13–15, 2025; Holiday Inn Express Valencia-Ciudad las Ciencias
Valencia, Spain

62nd Annual Meeting of the International Association of Forensic Toxicologists
(*https://www.tiaft2025.com*)

Nov. 23–27, 2025; New Zealand Int. Convention Centre
Auckland, New Zealand

20th Annual Pre-Filled Syringes & Injection Device Forum
(*https://www.pharmaedresources.com/events/*)

Dec. 9–10, 2025; TBA[a]
La Jolla, CA, US

American Academy of Forensic Sciences — 78th Annual Meeting (*https://www.aafs.org/*)

Feb. 9–14, 2026; New Orleans Ernest N Morial Convention Center
New Orleans, LA, US

PainConnect 2026
(*https://painconnect.org/*)

May 5–8, 2026; Grand America Hotel
Salt Lake City, UT, US

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

March 7–11, 2026; Henry B. González Convention Center
San Antonio, TX, US

18th Annual BBC (Behavior, Biology, and Chemistry) Meeting: Translational Research in Substance Use Disorders
(*https://ww2.uthscsa.edu/artt/bbc/index.asp*)

March 20–22, 2025; Embassy Landmark San Antonio
San Antonio, TX, US

2026 American College of Medical Toxicology Annual Scientific Meeting
(*https://www.acmt.net/annualmeeting/*)

March 20–22, 2026; Hilton Boston Park Plaza
Boston, MA, US

The SOT 65th Annual Meeting and ToxExpo
(*https://www.toxicology.org/events/am/AM2026/index.asp*)

Mar. 22–25, 2026; San Diego Convention Center
San Diego, CA, US

ACS Spring National Meeting & Exposition 2026
(*https://www.showsbee.com/fairs/62293-ACS-National-Meeting-Exposition-2026.html*)

Mar. 22–26, 2026; TBA[a]
Atlanta, GA, US

2026 Addiction Medicine Conference
(*http://addiction-medicine.org/spring-conference/*)

April 10–11, 2026; Renaissance Asheville Hotel; Virtual
Asheville, NC, US

Southern Association of Forensic Scientists — 2026 Annual Meeting
(*https://safs1966.org/annual-meeting/*)

April 13–17, 2026; TBA[a]
Greenville, SC, US

104th California Association of Criminalists Seminar
(*https://www.cacnews.org/events/seminar/seminars.shtml*)

April 26–May 1, 2026; DOJ Riverside Criminalistics Laboratory
Temecula, CA, US

American Psychiatric Association 2026 Annual Meeting
(*https://www.psychiatry.org/*)

May 16–20, 2026; TBA[a]
San Francisco, CA, US

American Society of Crime Laboratory Directors — 53rd Annual Symposium
(*https://www.ascld.org/ascld-annual-symposium/*)

May 17–21, 2026; DeVos Place Convention Center
Grand Rapids, MI, US

44th International Symposium on Capillary Chromatography and 21st GC×GC Symposium
(*https://www.chromaleont.it/iscc*)

May 17–22, 2026; Congress Centre
Riva del Garda, Italy

The Association of Firearm and Tool Mark Examiners — 57th Annual Training Seminar
(*https://afte.org/meetings/annual-seminars*)

May 24–29, 2026; Baltimore Marriott Waterfront
Baltimore, MD, US

2026 Association for Psychological Science Annual Convention
(*https://www.psychologicalscience.org/conventions/2026-aps-annual-convention*)

May 28–30, 2026; International Barcelona Convention Center
Barcelona, Spain

74th ASMS Conference on Mass Spectrometry and Allied Topics
(*https://asms.org/conferences/annual-conference*)

May 31–June 4, 2026; TBA[a]
San Diego, CA, US

The College on Problems of Drug Dependence Annual Meeting
(*https://cpdd.org/meetings/current-meeting/*)

June 13–17, 2026; Oregon Convention Center in Portland
Portland, OR, US

Northwest Association of Forensic Scientists — 2025 Annual Conference
(*http://nwafs.org*)

TBA, 2025; TBA[a]
TBA, US

Mid-Atlantic Association of Forensic Scientists — 2025 Annual Meeting
(*https://www.maafs.org/annual-meeting*)

Oct. 4–8, 2026; Kalahari Resort
Pocono Manor, PA, US

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[a]TBA: To be announced.

Forensic Science in Ireland

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Introduction

The island of Ireland is situated in northwestern Europe. It comprises the 26 counties of the Republic of Ireland (officially named Ireland) and the 6 counties of Northern Ireland, which is part of the United Kingdom. Ireland is a member of the European Union (EU). The population of Ireland (Republic) is 5.38 million, giving a population density of 73 people per square kilometre [1]. Ireland has a single national forensic science laboratory known as Forensic Science Ireland (FSI) and a single national police force known as An Garda Síochána (AGS), ("*Guardians of the Peace*" in the Irish language). FSI is a non-statutory executive agency of the Department of Justice, has over 200 staff and a budget of €30+ million [2]. It holds a unique place in the criminal justice system and operates as an independent specialised executive agency, providing specific scientific services to assist the investigation of crime. AGS has over 14,000 police officers and an overall budget of €2+ billion [3]. It has a primary duty and responsibility, as the national police force in Ireland, to investigate crime. Separate to criminal investigation units, specialised units within its organisational structure also deliver forensic science services through Divisional Crime Scene Investigation Units (DCSIU) and a specialised national unit, the Garda National Technical Bureau (GNTB).

The Irish legal system is adversarial and based on common law, which is a legal system that recognises case law as capable of establishing laws (judge-made law). The Irish Free State was established in 1922, and a constitution was introduced. This constitution was not accepted by all political parties at the time, and a new constitution called Bunreacht na hÉireann ("*Constitution of Ireland*" in the Irish language) was passed by popular referendum in 1937 [4]. Original statutes in Ireland were directly inherited from the United Kingdom parliament. This influence is still evident to the present day in some areas of legislation, such as the Explosives Act, 1875 and Explosive Substances Act, 1883 [5,6]. An adversarial court system involves legal representatives taking opposing sides during the criminal trial process. The burden of proof in a criminal trial is on the State, which must prove the guilt of the accused beyond a reasonable doubt. The interests of the accused person are represented by a lawyer who advocates on behalf of the client. Forensic science findings and expert witness reports are subjected to the rigors of courtroom examination-in-chief and cross-examination by opposing sides during criminal trials. The majority of forensic practitioners in Ireland are afforded the status of expert witness in the courts. An expert witness, regardless of which side calls them, is expected to provide impartial, objective, and factual evidence within the scope of their competence. An expert witness is afforded greater leeway than the lay witness to proffer opinion as evidence. There is no register of expert witnesses or system of pre-qualifying an expert witness in Ireland. It is therefore incumbent upon the court to satisfy itself as to the expert status of such a witness in each case. This is usually established during direct evidence to the court and can be subject to challenge through cross-examination.

Court trials involving serious crimes in Ireland take place in the higher courts – Circuit Criminal Courts and Central Criminal Courts, with a sworn jury in place and a judge presiding. Legislation allows for the establishment of non-jury courts known as the Special Criminal Courts. The first of these courts was established and has been operating since 1972. These courts were set up as a response to concerns of jury intimidation and tampering where the "*Government is satisfied that the ordinary courts are inadequate to secure the effective administration of justice and the preservation of peace and order*" [7]. Traditionally, the Special Criminal Court has dealt with terrorist offences, and more recently trials dealing with organised crime and gangland criminal activities have been held there. These courts have no jury and are presided over by three senior judges. The court's decision is that of the majority.

Forensic science services provided to stakeholders are funded by central government as a "not for charge" model. Investigating police officers work with the forensic service provider to develop an appropriate examination strategy that will effectively progress the case. The selec-

tion of items for testing is predefined in some instances, for example blood samples taken under road traffic legislation. A more collaborative approach is required in other instances, for example murders, sexual and serious assaults, and burglaries, where examinations and analysis depend on context and case circumstances. The application of a case assessment and interpretation (CAI) approach helps provide robust, reliable expert opinion reports on criminal investigations. Service-level agreements between AGS and forensic service providers, detailing agreed responsibilities, maximise the effective use of resources.

Establishment of Various Forensic Science-Related Institutions

History and Establishment of the Technical Bureau

The development of a forensic science service in Ireland aligns with that of other parts of the world. The first forensic science laboratories were developed by police forces arising out of the need to better investigate suspicious deaths and crimes. The establishment of the Irish Free State in 1922 brought with it many new institutions of government, not least of which was a new police service. Prior to the founding of the State, and while under British rule, the country had been policed by two distinct forces: the majority of the country was policed by the Royal Irish Constabulary (RIC), while the metropolitan region encompassing the capital city, Dublin, was policed by the Dublin Metropolitan Police (DMP). In 1922, the RIC was replaced by a new police force, An Garda Síochána. In 1925, the DMP was amalgamated into AGS, creating a single, national police service which remains to this day [8].

At the inception of the new force, the capacity for the effective investigation of crime was extremely limited, therefore, the new service inherited almost no capacity for scientific or forensic investigation. In September 1931, the Garda Commissioner solicited opinions and ideas for suggestions and innovations to modernise the force. In 1933, an editorial in The Garda Review, the periodical published by AGS, titled "*Science and the Police Officer*" lamented the fact that the organisation lacked the invention and innovation available to other police forces [9]. A subsequent article stated:

> *"In the detection of crime nowadays little is left to chance. The analytical microscope of science is focussed upon the minutest object of suspicion. The chemist's laboratory with its test tubes, re-agents, spectroscopes, microscopes, X-ray apparatus, and the photographer's camera all unite to assist our normal senses and to conjure up or reject possible or improbable evidence, as the case may be."* [10]

A further series of articles published later that year detailed the application of science on subjects including fingerprint identification, the development and photography of fingerprints, and firearms identification [11–13].

The requirement for specialisation was identified by leadership in AGS, and a report in 1933 highlighted cases where crucial evidence and investigation time were lost due to a lack of technical expertise. This report called for the establishment of "*a special group of men in whose hands we could with confidence place the investigation of crime*", citing examples from the police services of Paris, Berlin, and Vienna [14].

On the 9th of July 1934, a circular was issued from Garda (Police) Headquarters formally proposing the establishment of a Scientific Bureau. It sought applications from police officers who held qualification, training, or skill in the following areas:

- Chemistry
- Physics
- Pathology
- Wireless Telegraphy
- Handwriting
- Ballistics
- Photography
- Use of Microscope
- Engineering (Civil, Mechanical, Electrical)
- Making of Models
- Language

The circular further proposed that any police officer who was not possessed of such skills, but "*may have evinced an interest in or an ability to acquire technical knowledge*" may be offered the opportunity to "*benefit from a course of special training in the application of science to crime detection*". Three months after the circular was issued, on the 7th October 1934, the Technical Bureau of AGS was formally established. At the foundation of the Bureau, a board of experts was empanelled. This board included two lawyers, an ordnance officer and ballistics expert with the National Army, an expert on forged and suspect documents, the State Forensic Pathologist and a purveyor of precision optical instruments and photographic equipment [15].

At its inception, the core of the Technical Bureau was the Investigation Section. This Section, rather than being forensic in nature, was dispatched to incidences of serious crime nationwide to provide a dedicated and professional criminal investigation service. The Investigation Section were at liberty, however, to draw on the skills of the other specialist sections within the Bureau [14]. By the late 1930s, the structure of the Technical Bureau was divided into five Sections. Alongside the Investigation Section, it consisted

of a Habitual Criminal Registry Section which further incorporated a fingerprint sub-section. There was also a Ballistics Section with microscopy and micro-photography sub-sections, a Photography Section, and a Mapping Section. The Technical Bureau outsourced questioned document and handwriting examinations until 1973, when a Documents and Handwriting Section was established.

History and Establishment of the National Forensic Science Laboratory

By 1960, developments in analytical chemistry and biological techniques allowed for more probative evidence to be obtained from forensic samples. This meant that more specialist scientific skills were required to exploit these benefits. Crimes such as murders and sexual assaults, which needed greater scientific expertise to use these techniques, were outsourced to the Metropolitan Police Laboratory (UK) or other agencies within the State such as An Foras Talúntais ("*The Agricultural Institute*" in the Irish language), the Institute of Industrial Research and Standards (IIRS), and The State Laboratory. In 1972, a sub-committee from the National Science Council recommended that AGS needed the services of a forensic science laboratory. In 1975, the Department of Justice appointed the first State forensic scientist, Dr Jim Donovan, and established the Forensic Science Laboratory (FSL), later renamed Forensic Science Ireland (FSI). The establishment of a national forensic science laboratory set out clear lines of responsibility that anything to do with criminal matters would come under the remit of FSI, an agency of the Department of Justice. In 1978, it relocated to Garda (Police) Headquarters, situated in the Phoenix Park, Dublin. This relocation allowed the recruitment of additional specialist staff and a broader range of forensic services to be provided. By 1980, there were two distinct scientific sections (Biology and Chemistry) in FSI. Many drugs were controlled under the Misuse of Drugs Act, 1977. The small number of drugs seizures in Ireland at this time were analysed by the College of Pharmacy in Trinity College Dublin (TCD). The drug situation changed rapidly in Ireland from 1980, with significant increases observed in the use and seizure of drugs. This led to FSI establishing a dedicated Drugs Section in the early 1980s. Additional legislation introduced in 1984 permitted FSI staff to provide a certificate of analysis to the court. The benefit of this change meant that FSI staff were no longer required to attend court in all drugs cases. FSI continued to grow and develop, being a founding member of the European Network of Forensic Science Institutes (ENFSI) in 1995. As demand for FSI services grew, several strategic reviews were undertaken. The 2007 Kopp report [16] identified the need for additional staff and resources to address suppressed demand and to prepare for the future implementation of DNA database legislation. FSI was named as the custodian of the national DNA database in the Criminal Justice Forensic Evidence Act, 2014. This legislation allowed for the establishment of the Irish DNA database system. In 2023, FSI relocated to a purpose-built facility alongside the government laboratories of the Department of Agriculture, Food and the Marine and The State Laboratory, all based on the Backweston Science Campus outside Celbridge, Co. Kildare. This state-of-the-art facility provides significant infrastructural benefits to FSI, including enhanced environmental control systems to reduce the risk of contamination as forensic technologies become more sensitive. FSI continues to make a significant contribution to international collaborative working groups, such as ENFSI and the Association of Forensic Science Providers (AFSP) [17].

The State Laboratory

The State Laboratory was established in 1924 and came under the remit of the Department of Finance. It provides an analytical service and specialist advice to a range of government departments and public sector bodies. Its initial focus was to ensure that the appropriate Customs & Excise taxes, levies, and rebates were correctly applied to alcohol, fuel, and animal feeds. Over the years, as there was no established government laboratory for criminal casework, miscellaneous items from criminal investigations were sometimes presented for analysis. Its current remit includes a post-mortem forensic toxicology service to coroners and the Office of the State Pathologist (OSP).

Coroner and Forensic Pathology Services in Ireland

In Ireland, legislation consolidating the law and duties of the role of the coroner came into being with the Coroners (Ireland) Act, 1846 [18]. The Coroners Act, 1881 stipulated that candidates for the role of Coroner must either be a qualified medical practitioner or legal practitioner. Thus began the shift towards a more scientific approach to the investigation of sudden and unexplained deaths. A Coroner is an independent public official who may call for a post-mortem examination and will preside over the inquest into the circumstances of the death. The role of the coroner is judicial rather than a medical one. The function of the inquest is to determine the facts of "who, when, where, and how" a death occurred if sudden, violent, or otherwise unnatural. Forensic pathology services in Ireland are provided by the Office of the State Pathologist (OSP) [19]. The OSP was formally established in 1973 as a non-statutory state agency under the Office

of the Attorney General. Prior to this, individual pathologists contracted to perform post-mortem examinations for evidential purposes held the informal title of State Pathologist.

Currently, the OSP has a staff of five forensic pathologists, headed by the Chief State Pathologist and supported by laboratory and administrative staff. The OSP provides an on-call service conducting post-mortem examinations in all cases where death is suspected to be the result of criminal actions, or where a death takes place in a custody setting. They may also perform a post-mortem examination if the death is unexplained or unusual. Where appropriate, the pathologist will attend the crime scene, usually alongside GNTB investigators. The OSP may also involve additional specialists where it is necessary in certain investigations, such as anthropologists, entomologists, or paediatric and perinatal pathologists. Such specialists are not employed by the OSP but are engaged on an as-needed basis. In 2023, the OSP conducted post-mortem examinations in 192 cases of suspicious or unexplained deaths [20].

Medical Bureau of Road Safety

The Medical Bureau of Road Safety (MBRS) was established in 1968 as an agency under the aegis of the Department of Transport [21]. It provides analytical and advisory services to the Courts Service of Ireland, AGS, and the Irish Aviation Authority (IAA). Laboratory testing is carried out to determine alcohol levels in blood or urine samples of people suspected of driving under the influence of alcohol. The original blood alcohol limit of 125 mg% has been incrementally lowered to the current 50 mg% (20 mg% for professional drivers) alongside an increase in scope to cover driving under the influence of drugs. The MBRS remit has expanded over the years from laboratory-based alcohol quantification of collected blood and urine samples to supporting and maintaining evidential breath testing equipment across police stations nationwide. They also provide roadside drug test kits alongside their laboratory-based drug analysis and quantification of driver's blood and urine samples. MBRS forensic services relate to road traffic offences, issuing certificates of analysis to the courts and providing training and advice to the police [22].

University Degree Programmes in Forensic Science

A significant amount of on-the-job training and continuing professional development (CPD) occurs within the specific forensic disciplines of the major forensic service providers in Ireland. Outside of these organisations, formal educational training in forensic science undergraduate degree courses (or forensic science offered in combination with another science discipline) takes place in Irish universities. University degree courses are typically accredited by the Chartered Society of Forensic Sciences (CSFS), a UK-based organisation, that is an internationally recognised professional body supporting forensic practice worldwide [23]. Atlantic Technological University (ATU) offers forensic science at its Galway and Sligo campuses. Technological University Dublin (TUD) offers forensic science at its Tallaght campus. Technological University of the Shannon (TUS) offers forensic and pharmaceutical science, while University College Cork (UCC) offers chemistry with forensic science [24–28]. Currently, there is no postgraduate master's degree programme in forensic science on offer in Ireland.

Performance of Various Forensic Science-Related Functions

Crime Scene Investigation

From 1934, the Investigation Section of the Technical Bureau would deploy with Garda photographers and cartographers to document the crime scene, along with any other skill sets available within the Bureau as necessary. This precipitated the earliest dedicated crime scene investigation element within AGS. A dedicated police photography element was first established in 1926, primarily to train recruits in the use of cameras [29]. The police officers who were responsible for this training were subsumed into the Technical Bureau as the Photography Section, and tasked with the photography of crime scenes, post-mortems, and exhibits. The Mapping Section was established in 1934 within the Technical Bureau to provide cartographers and draughtsmen to record crime scenes and prepare maps or plan drawings for any judicial proceedings [30]. The Mapping Section also employed model makers to construct scale models of crime scenes as a visual aid in criminal trials. The finite resources of the Technical Bureau limited their availability to instances of serious crime. To facilitate the investigation of volume crime, selected detectives across the country were trained in the examination of crime scenes and carried out this role in addition to their other responsibilities. In 2002, dedicated full-time Crime Scene Investigation Units were established nationwide. Currently, there are two distinct elements providing a CSI service within AGS. The operating model divides the country into twenty-one geographical divisions. Each of these divisions is served by a DCSIU and are primarily tasked with the forensic investigation of volume crime.

The second element responsible for providing a CSI service is the Garda National Technical Bureau (GNTB). GNTB crime scene investigation teams are tasked with the

forensic investigation of serious and complex crime scenes, primarily homicides, as well as crime scenes relating to counterterrorism, national security, or serious organised crime investigations. GNTB teams deploy nationally under the direction of a Crime Scene Manager and are comprised of specialists with dedicated roles within a team. GNTB teams bring a greater expertise and enhanced capacity to the investigation of serious crime, while ensuring the DCSIU personnel remain available to deal with volume crime for the duration of any major investigation. Additional specialist capabilities provided by GNTB teams can include shooting incident reconstruction, post-blast investigation or chemical enhancement, and 3D modelling of crime scenes. GNTB have agreements to provide specialist Crime Scene Investigation services if required by outside agencies, for example the Military Police Corps of the Irish Defence Forces [31]. FSI staff also attend crime scenes, including clandestine laboratories and large seizures of drugs when requested by AGS.

Training for Crime Scene Investigators is given in the Garda Síochána College, where the majority of training is provided by FSI and GNTB personnel. Courses include Crime Scene Investigation, Fire and Arson Investigation, and Crime Scene Management. Ongoing CPD opportunities and training undertaken by GNTB with partner agencies and institutions overseas allow best practice to be cascaded throughout all CSI elements within Ireland.

GNTB also act as the Disaster Victim Identification (DVI) team for Ireland and are responsible for all facets of the Post Mortem phase of DVI in conjunction with the OSP. In this role, GNTB will deploy overseas as required where Irish citizens have been victims in mass fatality incidents, usually as part of a coordinated international law enforcement response [32].

All CSI elements in Ireland are primarily empowered via the legal provisions contained within the Criminal Justice Act, 2006 [33]. This provides the authority to designate a place as a crime scene and confers the power to examine, record, seize, and retain evidence. Under this legislation, all crime scene investigators responsible for seizing and recovering evidence are required to be serving police officers.

Chemical Analysis

The Drugs section in FSI is responsible for the analysis of seized items suspected of containing controlled substances. As with other evidence types examined in FSI, the primary source of exhibits come from seizures made by AGS, with Customs & Excise also being a source of seized material. The applicable drugs legislative acts in Ireland specify drugs that are controlled (an offence to possess without a prescription). The most commonly reported drugs in the certificates of analysis issued by FSI are cannabis (42%), cocaine (26%), and diamorphine (6%) [34].

Ongoing collaborations with stakeholders across the criminal justice sector have shown progress in presumptive drug testing (PDT). In certain cases of simple possession for personal use, frontline police officers with appropriate training utilise PDT, which can help divert casework from undergoing a full suite of analysis in FSI.

While the routine analysis of drugs is well understood and relatively standardised, the evolution of the drugs market presents analytical and public health challenges. Well-established analytical techniques such as GC-MS and LC-MS continue to be the primary methods of bulk drugs analysis worldwide. In the controlled drug market, most of the evolution has taken place with regard to the evidence/analytes being tested for. This is in contrast to other areas of forensic analysis (e.g., DNA) where significant developments continue to occur in the analytical technology. Recent examples of new drug products detected by FSI include potent synthetic opioids such as *N*-pyrrolidino protonitazene being sold as heroin (diamorphine) and a range of synthetic cannabinoids (e.g., MDMB-4en-PINACA, ADB-BUTINACA, and Hexahydrocannabinol (HHC)) being sold as edible "THC/Cannabis" products. Incidences of poisoning associated with the illegal supply of these mislabelled substances have been linked to hospitalisations and overdoses [35]. In response to these and similar challenges, the Drugs Section have been involved in developing multi-agency response protocols with relevant national partners. FSI report novel detections each year to the EU Early Warning System (European Union Drug Agency) as part of a European network enhancing the ability of member states to respond efficiently to emerging and novel drug threats.

Case Study 1: International Plot to Smuggle Cocaine

In 2014, the *Makayabella*, a 20-metre luxury yacht, was loaded with over a tonne of cocaine off the coast of Venezuela and set sail across the Atlantic to within 200 miles of the Irish coast, where they were set to rendezvous with another vessel to offload the illicit cargo. After a calamitous journey they were intercepted and boarded by the Irish Navy. A total of 1,025 kilogramme blocks of high-purity cocaine contained in 41 packages, destined for the UK market, with a street value of £164m were discovered. Jail sentences totalling 31 years were handed out to the four crew members for their part in the international plot to smuggle cocaine. This shows the transnational reach of drug gangs, and the importance of a cohesive multi-agency (national and international) response to effectively combat drug crime.

Forensic Chemistry/Trace Evidence

After the forensic science laboratory was established, the 1980s saw demand grow rapidly for both forensic services and forensic expertise in an increasing range of evidence types. In the early 1970s, republican militants began a campaign of violence in Northern Ireland commonly referred to as "*The Troubles"*. Associated criminal activities taking place in the Republic of Ireland included the development and manufacture of explosive substances and fundraising through armed robberies. This required the expansion of processes and analytical techniques to forensically examine trace evidence, firearms, and explosives seized during criminal investigations.

Case Study 2: Five Finger Strand Arms and Explosvies Find

In January 1988, a major arms and explosives find occurred on Five Fingers Strand, Co. Donegal, an area of isolated coastline in the northwest of Ireland. The items recovered were in good condition, having been wrapped in cellophane and stored in two large oil drums buried horizontally in sand dunes. Their contents were found to include 4 FN MAG light machine guns, 100 Kalashnikov AKM rifles, 48,570 rounds of assorted ammunition, 3,000 metres of detonating cord, and over 100 lbs of Semtex-H plastic explosive. The total weight of arms in this "hide" was 2½ tonnes. This find illustrates the importance of good forensic intelligence and recovery, and indicates the threat that Ireland was facing at the time.

Semtex-H, a Czech-made plastic explosive, was first encountered and analysed by the laboratory in 1986. This explosive is widely reported to have been imported from Libya in tonne quantities and would continue to feature in explosives casework in FSI over the following decades [36]. A common use of Semtex was in improvised mortars as the main charge or as a booster charge for fertiliser-based homemade explosives.

FSI has a wide array of chromatographic, microscopic, spectroscopic, and physical comparison techniques at its disposal. As a single national forensic science laboratory, FSI carries out the analysis, examination and reporting on a comprehensive suite of traditional forensic chemistry evidence types such as paint, glass, textile fibres, gunshot residue (GSR), explosives, fire accelerants, inks and dyes, soil, footwear and tyre marks, incapacitant sprays, and physical fits. Many of these "traditional" trace evidence types (e.g., paint, glass, textile fibres, GSR, footwear and tyre marks) are reported using the "Expert Evaluative Opinion" reporting framework. FSI staff sit on a wide range of ENFSI working groups focused on the analysis and reporting of trace evidence as well as being active members of AFSP working groups with UK and Northern Ireland colleagues.

Case Study 3: Murder of Lord Louis Mountbatten

In August 1979, Lord Mountbatten, second cousin to Queen Elizabeth II, was one of the casualties killed by an explosive device planted on his fishing boat, Shadow V. Also on board at the time of the explosion were members of his family and crew members. A 50 lb gelignite bomb had been planted by a member of the Irish Republican Army (IRA) during the night, while the boat was harbouring in Mullaghmore, Co. Sligo. The following day when the boat was sailing just a few hundred metres from the shoreline, the device was detonated by radio control, killing several people onboard, including Lord Mountbatten. The trace forensic evidence recovered in this case included matching multi-layered paint flakes from the boat and traces of nitroglycerine explosive found on the suspect's clothing, providing the critical link between the suspect and the bombing incident. The suspect was later found guilty of murder. This case is a good example where recovery and analyis of forensic evidence were critical to a sucessful prosecution.

Forensic Toxicology

Forensic toxicology analysis in Ireland is mainly carried out by three governmental organisations (FSI, The State Laboratory, and MBRS) with the principal differences observed in case types and the reporting and interpretation services provided. FSI provides toxicology services relating to drug-facilitated crime, predominantly sexual assault cases. The collection of forensic case samples (toxicology and biological/DNA samples) is usually carried out by specially trained medical staff in Sexual Assault Treatment Units (SATU). The laboratory analysis provided covers a wide range of analytes, including alcohol and drugs. The reporting of results is in the form of statements of evidence which include interpretations such as alcohol back-calculations to provide an estimate of the blood alcohol concentrations at an earlier time point, and information on typical effects and detection windows of alcohol and drugs.

The State Laboratory provides post-mortem toxicology services on behalf of the Coroners Service and OSP. Given post-mortem toxicology can be required in unexpected as well as crime-related deaths, this analysis covers a wide range of analytes including alcohol, drugs, and other toxic substances (e.g., carbon monoxide). The reporting of results is typically issued to the coroner or pathologist. These toxicology results are interpretated in conjunction with any other medical and pathology findings. The MBRS provide toxicology services relating to road traffic offences. This is provided through the quantitative analysis of driver's blood and urine samples for drugs and alcohol present, alongside supporting the testing equipment

used across the police network. Results are reported under the relevant road traffic legislation certifying the presence and concentration of drugs and/or alcohol detected. Similar analytical detection technologies are used across the organisations, including GC-FID, LC-MS/MS, and high-resolution mass spectrometry. The laboratories are all active members of the United Kingdom and Ireland Association of Forensic Toxicologists (UKIAFT) [37].

Fingerprints

In 1903, staff of the DMP underwent training at Scotland Yard in the relatively new discipline of Fingerprint Classification. A fingerprint record as part of the Habitual Criminals Registry was established within the General Prisons Board. On the establishment of the Free State, this register was subsumed into the Department of Justice and subsequently AGS in 1928. By 1939, the Fingerprint function was split into distinct sub-sections. Firstly, the Criminal Record Section who administered the registration of criminals and the maintenance of criminal records using the Henry Classification System. The second sub-section was the Single Fingerprint Bureau, tasked to deal with the recovery and examination of marks at crime scenes, and the comparison of such marks using the Battley Single Digit Classification System. Over time, the Single Fingerprint Bureau evolved into the Fingerprint Section focusing entirely on the forensic and investigative aspect of its remit. Broadly, this encompassed crime scene investigation, chemical development of latent marks and the comparison and identification of fingerprints. Up to 1996, the fingerprint section was operated in a fully manual manner. The adoption of an Automated Fingerprint Identification System (AFIS) allowed for full database searching and introduced significant capacity gains. In 2019, the laboratory functions of the Fingerprint Section were divested to FSI. The CSI function remains within AGS while the mark searching, visualisation/mark development, and database management now occur within FSI. A recent upgrade in 2020 to a Multi-Biometric Identification System (MBIS) further improved the ability to carry out reverse database searches, with significant increases (up to 500%) in the number of returned putative identifications. The Fingerprint Section liaises closely with the Supplementary Information Request at the National Entries (SIRENE) Bureau of AGS. This is part of the Schengen Information System (SIS) – a widely used and large information sharing system for security and border management between all European countries [38]. Outside of the criminal investigation sphere, the Fingerprint Section also work closely with the International Protection Office, who are responsible for processing applications for international protection.

Ballistics

The earliest recorded use of forensic ballistics as evidence in Ireland was during the investigation into the murder of a police officer in Co. Clare in December 1925 [39]. Captain Daniel Stapleton, an Ordnance Officer with the National Army, gave evidence to the courts that in his expert opinion, a firearm produced by the prosecution as the murder weapon had discharged cartridges recovered from the scene. In 1933, prior to the establishment of the Technical Bureau, a detective stationed at Garda Headquarters undertook a correspondence course in ballistics with the intention of providing the required expertise from within the force. However, at a military tribunal in 1934, the competence of this detective to provide expert identification was questioned. A request from the court to review the evidence highlighted the shortcomings within the area of ballistics in the Technical Bureau. This competency gap was remedied by the transfer of Daniel Stapleton to the bureau in the role of ballistics expert up to his retirement in 1959. As of 1939, the primary function of the section was listed as the examination of all exhibits connected to crime involving firearms and explosives, along with the microscopic examination of other exhibits, restoration of erased serial numbers, and the analysis of glass fractures [30].

The political situation on the island of Ireland in the latter half of the 20th century required a well-resourced capacity in the forensic examination of firearms, ammunition, and related evidence. The Ballistics Section, established in 1934, has been in continuous existence from that time. Based in Garda Headquarters in Dublin, the Section is the State's sole forensic firearms laboratory. The primary role is the examination and legal classification of all recovered firearms and ammunition [40]. Examinations include condition, serial number restoration, and documentation of defects or alterations, which may have a bearing on use or misuse. All firearms are test fired in a dedicated forensic range on site to confirm functionality, establish lethality, and to recover exemplars of discharged cartridge cases and bullets. The Section retains all discharged ammunition components recovered from crime scenes nationally. All recovered discharged ammunition and test-fired ammunition are cross-correlated using an automated ballistic identification system (IBIS^{TM}). Potential links highlighted are confirmed to an evidential standard using comparison microscopy. The Section was a founding member of the Interpol Ballistics Information Network (IBIN), allowing participating agencies utilising IBIS^{TM} technology to perform targeted international correlations. GNTB firearm experts hold membership of professional bodies including the CSFS and the Association of Firearm and Toolmark Examiners (AFTE) and collaborate with bodies such as ENFSI [23,41].

DNA and Biological Analysis

1994 saw the first use of DNA evidence in a criminal trial in Ireland. Later that year, forensic DNA profiling was set up in FSI and DNA findings were routinely used in casework. In 2003, the Department of Justice began the process to allow for the establishment of a DNA database system in Ireland. DNA databases were already in use in many jurisdictions around the world, including the UK (established in 1995) and in the United States (federal database established in 1998). In 2014, legislation was passed which allowed samples to be taken for DNA profiling and storage on a database system [42]. In this legislation, FSI was named as the custodian of the national DNA database. In parallel with developments in DNA profiling technologies used by FSI (SGM Plus™, Y-STR, NGMSElect™, NGS mitochondrial), the risk of contamination has significantly increased compared to earlier sequencing and typing technologies, such as single locus probe and ABO blood typing. FSI utilises ISO cleanroom suites with pressure cascades for all aspects of DNA evidence recovery, sample processing, and profiling activities to minimise the risk of environmental contamination. The search and recovery of biological trace evidence, body fluid source attribution, blood pattern analysis, and clothing damage assessments remain an important aspect of forensic casework. These screening methods both enhance the recovery of samples and aid in the interpretation of scientific findings. Cold cases are frequently reviewed with investigating police officers to progress these old cases using new technologies.

Ongoing developments in statistical interpretation tools (such as STRmix™ probabilistic interpretation software) have improved the ability to provide informative and interpretative results. More recently, Ireland was the first European country to begin using DBLR™ (database likelihood ratio) software for enhanced database searches. DBLR software allows FSI to carry out enhanced database searching using mixed DNA profiles. This has increased the usefulness of the database as it allows a much broader range of DNA profiles from crime scenes to be compared. The Prüm Treaty is a European cross-border information sharing framework that allows various types of information, including DNA profiles, to be exchanged with other EU Member States to help combat terrorism and international crime [2]. FSI plays a central role in the implementation of Ireland's obligations under Prüm, where the Irish DNA database (both crime and reference sample indices) forms part of a two-way information exchange with specified European partners.

As well as assisting in criminal casework, FSI has a humanitarian role in the identification of unidentified human remains to aid missing person cases. This work uses a separate index on the DNA Database System. This involves the DNA profiling of family members of missing persons and using national and international collaboration resources such as Interpol and the I-Familia database.

Case Study 4: Murder of Marilyn Rynn

In December 1995, Marilyn Rynn, a civil servant, disappeared after attending her workplace Christmas party. Two weeks later, her body was discovered on waste ground near her home. A forensic medical examination showed that she had been sexually assaulted and strangled. During the police investigation, a large number of people were interviewed and blood samples taken for purpose of DNA profiling. This was the first use of DNA mass screening in the State. Prior to his arrest, the suspect had searched online how long DNA could survive the natural elements. He consented to giving a blood test, falsely believing that any foreign DNA present on the victim would have degraded. The results of DNA profiling from semen recovered from the victim showed a match to his DNA, and he later received a mandatory life sentence for murder. DNA continues to be the area of most growth and development in forensic science.

Documents and Handwriting

Examination and analysis of questioned documents and handwriting was originally a function of the GNTB. This discipline was incorporated into FSI in 2019. The majority of examinations carried out relate to travel/identity documentation and the analysis of suspected counterfeit currency. The types of documents include passports, identification cards, and driving licences alongside a smaller volume of handwritten documents. Techniques used include a variety of image capture and alternate light sources, use of electrostatic detection devices to recover and enhance indentations, and expert examination of handwriting. An area of increasing challenge is in the examination of so-called "breeder documents" — basic documents such as birth, marriage and death certificates and baptismal records, used to support applications for identity, residency, and travel documents. These documents, which typically lack the security features associated with more robust documentation such as passports, are commonly encountered in relation to international protection applicants and refugee applicants. The Documents and Handwriting section work closely with Irish governmental agencies, such as the International Protection Office (IPO) and Immigration Service Delivery (ISD), providing both training

and analytical support. International collaborations with partner agencies to share information relating to breeder documents and connecting with international data sharing databases, such as the European Union-administered False and Authentic Documents Online (FADO), further assist this service in a constantly evolving world of increased population movement.

Cyber Forensics

To combat the growing trend of online fraud, online harassment, computer intrusions, and the examination of digital devices seized in the investigation of crime, AGS established the Computer Crime Investigation Unit in 1991, as part of the Garda Bureau of Fraud Investigation. The unit was later expanded into the Garda National Cyber Crime Bureau (GNCCB) in 2017. The GNCCB provides a national digital forensic service and encompasses units specialising in computer forensics, cybercrime investigations, cyber intelligence, cyber security, and cyber safety. These units comprise a blended staff model of police officers and civilian staff. In 2021, four satellite GNCCB hubs were created to provide a regional investigative capacity [43].

Reporting, External Verification, and International Collaboration

Forensic Reporting. The reporting of the significance of scientific findings in forensic science is a challenging area. The expert witness in court has a duty to ensure that the relevance of scientific findings in a case are neither overstated nor misunderstood. Developments since the 1990s propose activity-level proposition reporting known as Expert Evaluative Opinion reporting, alongside investigative or fact-based reports in certain case circumstances [44–47]. FSI have developed expertise in this reporting model and continue to contribute to this area through publications of papers relating to background levels, transfer and persistence of trace evidence [48–52], as well as the development of international best practice standards [53]. Only a small proportion of the total cases reported by FSI are suitable for this model of reporting. However, a subset of case types, for example paint, glass, textile fibres, GSR, and specific sexual assault cases, are more suited for evaluative reporting. Collaborations among forensic science providers and the broader scientific community continue to develop information and knowledge databases. This challenging yet important aspect of forensic science reporting continues to evolve.

External Verification and International Collaboration. FSI was awarded ISO/IEC 17025 accreditation by the Irish National Accreditation Board (INAB) in 2003. GNTB was awarded its ISO/IEC 17025 accreditation in 2015 in Ballistics. Forensic evidence types listed on the scope of accreditation at FSI include questioned documents and handwriting, textile fibres, glass, paint, hydrocarbon fire accelerants analysis/fire debris analysis, tear gases and pepper sprays (incapacitant sprays), GSR, bulk explosives, footwear marks, drugs, toxicology, fingerprints, DNA analysis, blood pattern analysis, body fluid identification, and physical damage to clothing. The scope of accreditation at FSI includes opinions and interpretation, including evaluative reporting, in many areas as well. The scope of accreditation for the Ballistics Section of the GNTB includes firearm identification and forensic classification, restoration of serial numbers, trigger pull, range of fire determination, kinetic energy of airguns, ammunition identification and forensic classification, comparison and identification of discharged ammunition.

FSI is a founding member of the European Network of Forensic Science Institutes (ENFSI) [54]. This is the main platform for international cooperation in Europe. This network of subject matter experts, founded in 1995, promotes and facilitates dialogue among practitioners of forensic science and the mutual exchange of information and shared experiences. There are 17 expert working groups covering different aspects of forensic science. FSI is an active participant in working group meetings and has hosted numerous meetings over the years.

FSI is also involved in the Association of Forensic Science Providers (AFSP) [17]. The AFSP are an independent, representative body of providers of forensic science services, both public and private laboratories, across Ireland and the United Kingdom. These laboratories work in partnership to promote public confidence in forensic science and develop quality and best practice in forensic science and forensic reporting. FSI engages with the drugs Early Warning and Emerging Trends (EWET) working group chaired by the Department of Health and the European Union Drugs Agency (EUDA), formerly the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA), and UKIAFT [37,55]. FSI also cooperates with Forensic Science Northern Ireland (FSNI) under the aegis of the North/South Intergovernmental Agreement (IGA) on Criminal Justice Co-Operation. FSI engages in the mutual exchange of information via the Prüm, Schengen Information System (SISII), and Supplementary Information Request at the National Entries (SIRENE) mechanisms that support enhanced cooperation for security and border management in Europe.

Conclusion

A single national forensic science laboratory and a single police force in Ireland facilitate enhanced co-operation in the provision of a high quality, integrated forensic science service across the nation to support the Irish criminal justice system. Accreditation of laboratories delivering these critical services in Ireland ensures the highest international standards are maintained and externally verified. The delivery of forensic science services in Ireland is a "not for charge" model and examination strategies are based on case circumstances in collaboration with the investigating forensic experts. A movement towards expert evaluative opinion reporting in suitable case types ensures forensic evidence reporting is fair, impartial, and balanced, and that the scientific findings in a case are not misstated. Investment in state-of-the-art forensic facilities, such as ISO standard cleanrooms to support DNA and trace evidence examinations, and continuous technological updates allow the delivery of forensic services in Ireland to keep pace with best international practices. Ongoing interaction, information exchange, and cooperation with the worldwide forensic community are key features which allow Ireland's forensic services to continue to develop.

Moving forward, forensic science in Ireland would benefit from strengthening links between FSI and universities by establishing research collaborations and developing work experience opportunities for students. Building new and expanding on existing knowledge databases will support the provision of more effective communication on the significance of scientific findings in expert evaluative reporting. Continuing and strengthening ongoing collaborations among the core forensic science providers in Ireland will maintain awareness of growing and emerging threats and the analytical challenges they present. This will ensure the integrated Irish forensic science model continues to defend against current and future domestic and transnational threats.

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ADVANCING THE PRACTICE OF FORENSIC SCIENCE IN THE UNITED STATES

Revealing the Web of Connections: Crypto Scams, Online Drug Sales, and Financial Crimes

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The Dark Web

Cryptocurrency

The technology required to enable the dark web, The Onion Router (TOR), was originally introduced by researchers funded by the Office of Naval Research. It created a new class of websites that were privacy-preserving. To reach dark web websites, visitors use a unique browser that obscures the route from visitor to server through a constantly changing network of routes. TOR promised that the routes would never be logged, making the traffic untraceable. While it has been available since 2002, it was the introduction of cryptocurrencies that enabled the "dark markets." Combining TOR with cryptocurrency caused an explosion in online sales of drugs, weapons, stolen credit card data, murder for hire, narcotics, and pornography. With the location of the server obscured and with no reliance on a registrar to provide the domain name, the missing piece to Bitcoin's (BTC) adoption problem fell into place. The dark web offered websites that resisted the traditional technical countermeasures of the regulated internet, while cryptocurrencies offered a means of purchase that resisted the economic countermeasures of a regulated financial system.

Bitcoin began life in 2009 as a cryptographic puzzle solving a problem that mainstream America did not realize existed [1]: "Why should a central authority have the right to tell us what we can spend our money on and why should we pay them for this service?" [2]. It was first proposed in 2008 by Satoshi Nakamoto as a philosophical statement about freedom. It held an appeal to crypto anarchists and libertarians, and it existed as a theoretical currency for mathematicians and computer scientists [3]. But it was not an actual currency, rather a system for exchanging things of value represented on one side by physical goods and on the other by a symbol representing a set of guarantees. In the world of central banks, it is governments and global economies that assign the value to such symbols. But who would assign the value to the symbols representing this new "currency" that was not being used to purchase things of value apart from small transactions between the founding crypto anarchists and their disciples? From the first Bitcoin mined in 2009 until January 2011, the value of a Bitcoin never reached 50 cents [4]. What Bitcoin needed was a class of consumers who wanted to keep their transaction histories separate from their traditional bank accounts. In February 2011, customers of the dark market Silk Road used 9.5 million Bitcoin and the price soared from $1 to $174 per BTC by the time the FBI shut down the original Silk Road in October 2013. As Silk Road and other dark markets grew in popularity, the price of Bitcoin skyrocketed.

Dark Market Drugs: The Principle of Social Proof

While not the first TOR-based drug sales website, Silk Road brought to online drugs the missing pieces offered by the legitimate online sales world. The administrators guaranteed all sales, fulfilling the role offered by credit card networks. They also tracked the reputation of individual vendors, fulfilling the role offered by clear web marketplaces such as eBay and Amazon. With this system of trust in place, business began to boom, and the price of cryptocurrency began to soar [5]. Reputation tracking is an example of Robert Cialdini's principle of social proof, which says that people are influenced by the actions and opinions of others, especially if they see consensus [6]. When a vendor's "stats" show that they have sold heroin 1300 times with no bad reviews, it places the decision to buy heroin on a dark market into a community setting. The buyer is not acting alone, he is part of a social group who have all made this choice before.

While Silk Road and many other online "dark markets" have been shuttered as law enforcement has begun to use technology-based and other investigative techniques to bring down such marketplaces, the trust system has evolved. Marketplaces asked vendors to sign their accounts with a strong cryptographic key. This allowed the reputation earned on one platform to be transferred to other platforms. A vendor with 1,000 successful sales on Market A could share his cryptographic key to prove he was the same trustworthy merchant when beginning to sell on Markets B, C, and D. The keys offered on each marketplace could be compared to prove reliability, boost confidence, and allow new dark markets to quickly come online without having to start building a reputation from scratch. On the consumer side, security requirements in-

clude a waiting queue, anti-phishing CAPTCHAs, secret phrases, and canary tokens [7]. While the dark markets continue to be most famous for drug sales, many of the marketplaces offered every variant of illicit goods for sale, including malware, stolen identities, counterfeit documents, and data stolen from online breaches.

The Clear Web

The clear web has resulted in the evolution of a business model that minimizes geographic limitations to global markets, aids anonymity, and decreases cost. In the context of illicit markets, it is also assumed to have less risk for both seller and customer than face-to-face sales. Sales are generally through cyptocurrency, which can be purchased through dealers, ATMs, and exchanges and is believed to be anonymous [8]. There are three main differences between online and traditional drug dealing [9]. In drug dealing, trust is essential to avoid legal consequences, whereas in online sales, it is a means of attracting new customers and increasing sales. On the dark web, trust is promoted by the market administrators via third-party mediation, customer reviews, and vendor policies on delivery methods and seized shipments. Street dealers deliver products in private settings; online vendors use public mail services. Street deals require secrecy, face-to-face meetings, and cash. Online sales use public listings, covert electronic communications, and virtual currencies. There is a transparency paradox in that both the dark web and clear web are relatively anonymous but provide more data on the drugs, prices, quality, quantities sold, shipping, and customer satisfaction than is available on the street.

Pharmaceuticals

The earliest online sales of drugs on the clear web were pharmaceuticals. In the late 1990s [10], prescription drugs could be purchased from online pharmacies without a prescription. Sites that did require a prescription often had an "on-site" physician and a prescription could be obtained by completing a questionnaire. The drugs were 10% more expensive than a brick and mortar pharmacy, before shipping costs were added [11]. The online pharmacies could be identified by searches run on the search engines of the time, Excite, WebCrawler, Lycos, Yahoo!, AltaVista, and HotBot, and researchers used prescription drug names as the search terms. Alternatively, terms for pharmacies could be used, e.g. "internet pharmacy," "online pharmacy," and "online medicines" [12]. Issues with purchasing drugs online included receiving the incorrect drug, the wrong dose of the drug, or pills that contained no drug at all.

In the early days of internet commerce, illicit markets used traditional payment methods, including credit cards, wire transfer, Western Union, or PayPal. In response, the major credit cards would stop payments to merchant accounts that were found to be used to process payments for illicit goods, while online marketplaces were placed under increasing pressure to block these sales on their platforms. A list of sites prohibited from sales to the United States was maintained by the FDA. Criminal payment systems, such as ChronoPay, attempted to bypass this setback by mixing "bad money" with good, charging a premium when compared to traditional payment systems for the safety that their obfuscation provided. Illicit drug markets were able to exist and thrive thanks to these services. Online pharmacies such as Canadian Pharmacy [13] were found to have sold FDA-regulated drugs to hundreds of thousands of American households. The drugs most widely sold by illicit pharmacies were, and still are, erectile dysfunction drugs, including sildenafil, tadalafil, vardenafil, and their analogs. But these drug markets had strict rules against controlled drugs. They realized that as soon as they expanded their market to include the harder drugs, they drew law enforcement attention that caused their hosting companies and registrars to shut down their websites. By 2000, then-president Clinton proposed legislation to regulate online pharmacies. While legitimate online pharmacies did exist, they tended to be the internet version of established brick-and-mortar pharmacies. Prescription drugs that were also controlled substances began to be reported in 2003 [14].

On April 13, 2009, in response to the overdose death of Ryan Haight from controlled prescription drugs purchased from an illicit online pharmacy, the Ryan Haight Online Pharmacy Consumer Protection Act of 2008 prohibited the sale of controlled pharmaceuticals without an in-person examination by a physician [15]. While the act did provide a mechanism for the prosecution of vendors selling controlled pharmaceuticals online, by 2013, it was estimated that 86% of approximately 10,000 websites studied by the NAPB did not require prescriptions [16]. Illicit online pharmacies were being promoted by email spam, hacked web sites, search engine optimization, and forum/social media posts through a system of affiliate programs [17]. An affiliate program would provide website templates, drug fulfillment, payment processing, and customer service. The affiliate would send spam emails or use search engine optimization to drive customers to their websites. Spam campaign payments were made through Visa, MasterCard, American Express, and eCheck. An affiliate could earn as much as a 30–40% commission on sales. Three pharmacy affiliate programs produced over $180 million in sales [13].

Legal Highs

During the same time period, efforts to stop cocaine trafficking in the United States and MDMA in Europe had been relatively successful [18,19], resulting in a 77% reduction in price and a drop in purity to 46% for cocaine and a drop in purity resulting in almost no MDMA in products sold as ecstasy. But these drugs were quickly replaced with new drugs. Beginning in 2006, cannabinoid agonists and cathinone analogs, being sold as spice and bath salts respectively, dominated the clandestine drug markets. The scientific literature and patents were being searched for the synthesis and testing of drugs with the potential to affect the central nervous system. Only now, instead of buying illegal drugs on the street, spice and bath salts were being obtained online from Chinese chemical companies [20]. The pharmaceutical and chemical industry in China is extensive and chemicals that were not nationally controlled could be legally manufactured and exported, making online sales very attractive.

While the new drugs were not scheduled in the US either, the 1986 Federal Analogue Act [21] stated that any analog of a controlled substance sold for the purpose of consumption should be treated as a controlled substance. Consequently, many of the spice and bath salts were advertised online as "legal highs" or "research chemicals." The sites often qualified the products as "for research only" and "not for human consumption." These terms could be used to confirm that sites found using the search terms "buy" and a drug name were selling illicit drugs. The online vendors' tactics included providing quality service, competitive pricing, stealth techniques, and a slight excess of product by weight [22]. Customer loyalty was promoted through forum participation, timely communication, providing slightly more product by weight than promised, and avoiding customer disputes [9]. However, delivery of the specific drug that had been ordered was not guaranteed. The received product was often a different drug, a combination of drugs, or contained no drug at all.

The European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) Early Warning System began monitoring online drug sales in 1997 [25]. The number of new substances identified each year is shown in **Table 1** [23–26]. Using general search terms of "buy" with "legal highs," "research chemicals," and "herbal blends" or drug names, there was an increase from 170 websites identified in 2010 to 693 in 2012 [27]. The majority of the shops were based in the United States and the United Kingdom.

The path for online drug sales starts with an advertisement on the clear web. The drug is ordered online and paid for with cryptocurrency and delivered by post or a drop. Messenger services, social media platforms, and clear web platforms are also used to discuss drug sales. Each has its advantages for illicit trade. Clear web sites include websites, blogs, forums, and marketplaces. In social media, emojis, hashtags, and slang are used to bypass monitors. Messenger services use encryption for communication and sharing geolocation data.

Table 1. Novel psychoactive substances (NPS) reported by the European Monitoring Centre for Drugs and Drug Addiction by year

Year	NPS	Year	NPS	Year	NPS
2007	14	2008	13	2009	21
2010	41	2011	48	2012	74
2013	81	2014	101	2015	98
2016	66	2017	51	2018	55
2019	53	2020	46	2021	52
2022	41	2023	26	2024	47

Fentanyl and Fentanyl Analogs

After 2016, online drug trends for the US began to shift from cannabinoid agonists and cathinone analogs to synthetic opioids. This was a reflection of the pharmaceutical opioid crisis. Efforts to mediate the prescription opioid crisis resulted in an influx of black tar and powder heroin from Mexico. An exceedingly small amount of a highly potent synthetic opioid like fentanyl or its analogs could be added to powder heroin more easily than black tar, providing an advantage to dealers selling powder heroin. Fentanyl was also easy to synthesize and inexpensive to manufacture. Between 2010 and 2013, the number of heroin deaths doubled from 3,036 to 6,525. More significantly, from 2013 to 2023, fentanyl and fentanyl analog deaths rose from 3,105 to 73,838. Powder and tar heroin were distributed on the street through the established trafficking routes. However, like spice and bath salts, fentanyl and fentanyl analogs were easy and cheap to synthesize and a kilogram of the drug could be shipped in a standard shipping envelope. One kilogram of fentanyl from China sold for over $1 million on the street. The illicit online drug market was shifting from sales of $20 for 0.5 grams of a research chemical for personal use to kilograms of fentanyl to be distributed on the street.

China had controlled fentanyl and 11 analogs in 1996, six additional analogs in 2015, four in 2017, and two in 2018. As the analogs were scheduled, new analogs were synthesized and shipped to the US. The International Narcotics Control Board (INCB) identified over 150 fentanyl analogs between 2018 and 2023 [28]. Finally, in 2019, China controlled all fentanyl analogs [29]. In response, the

chemical factories' focus changed to fentanyl precursors which were then routed to Mexico and India. The precursors were used to manufacture fentanyl and distributed to the US. [30]. Where previously, fentanyl from Mexico was a minor, poor quality product, now it started to appear in counterfeit pills and as an adulterant in street drugs, including cocaine, marijuana, and vapes. The extreme rise in the drug overdose rate is due to the minute amount that constitutes a fatal dose of fentanyl. Poor quality control in the pill manufacture resulted in one pill with almost no fentanyl, while the next pill contained a fatal dose [31]. The increase in drug overdose deaths was a consequence of the inconsistent fentanyl concentrations and users being unaware of the fentanyl contamination in their drugs. After 2020, fentanyl analogs virtually disappeared from illicit drug sites.

Fentanyl precursors are also being shipped from China to India, which has become another source of illicit fentanyl. Online sales are not well regulated in India. India is also the source of the deadly fentanyl adulterant xylazine [32]. The online fentanyl market shifted from websites focused on selling to individuals to offering fentanyl precursors on business-to-business (B2B) sites. The B2Bs use different sales strategies, employing scientific nomenclature and chemical identification numbers on their web advertisements.

Finally, while online fentanyl sales dominate the drug scene due to their extreme overdose potential, research chemicals are still widely available on traditional illicit drug sites.

Crypto Investment Scams

For more than a decade, the number one financial crime in America, according to the FBI's Internet Crime Complaint Center, is business email compromise [33]. This changed suddenly and dramatically in 2022, with reported losses to "Investment Scams" jumping from $1.4 billion in 2021 to $3.3 billion in 2022. In 2023, the losses rose to $4.5 billion and in 2024 to $6.5 billion. Almost all of these losses can be more accurately labeled as "Crypto Investment Scams," with the FBI pointing out in their 2023 IC3.gov report that 85% of losses were due to investment scams that encouraged the victim to invest in cryptocurrencies. Over 58% of the total losses from all financial crimes involved cryptocurrencies. The Federal Trade Commission's 2024 "Consumer Sentinel" report revealed that while only 4.57% of complaints received were about investment scams, 45.57% of all online fraud was from this category. The IC3 report shared similar numbers, with 5.5% of victims accounting for 39.5% of all reported losses. When the astonishing losses of some of these victims is revealed, the negative public responses often take strong language that could be summarized as "How could anyone be that stupid?" To look at the problem more properly, the question should be rephrased as "What system of trust has caused this person to evaluate the investment so differently than the general public?"

In 2024, more than 13,000 websites reviewed were classified as "Crypto Investment Scams." From interviews with victims of these websites, three primary recruitment methods were identified, which can be described using the principles documented in Cialdini's book *Influence: the Psychology of Persuasion*. The method most described in the media is the romance-based crypto investment scams, which are often referred to as "pig butchering" after a Chinese term used by scam center operators. The term has been popularized in public advisories spread by Chinese authorities warning of the potential of human trafficking and financial loss related to these centers [34].

Using Cialdini's principle of liking [6], which states that people are more likely to comply with requests from those they like, this form of recruitment begins with an invitation to connect via an online dating site, a social media site, or a "chance meeting" that begins with a supposedly misdirected text message. As romance develops, the scammers learn more about their victim, guiding conversations towards a means by which all of their financial problems could be solved. In victim interviews, there have been several examples where the online lover claims to be a successful investor working at a major financial institution. But this is not the only way in which Cialdini's principles of persuasion are being used by scammers.

Returning to the principle of social proof [6], most of the crypto investment sites reviewed claim to have an affiliate program. In this type of affiliate program, the affiliates are provided with a registration code which, when used by a new investor to register with the site, promises to pay a commission to the affiliate. Based on this incentive, tens of thousands of individuals are posting "success stories" on social media where they claim to be the recipient of newfound riches because of their choice of investment platforms. In perhaps the most extreme recent example of this principle, an investment program calling itself Crypto Bridge Exchange (CBEX) was being touted on TikTok and other social media platforms across Nigeria [35]. This is the same acronym as that used by the China Beijing Equity Exchange [36] and is also listed on legitimate exchanges, although the currency has no value [37]. In a few short months, the sites had received "investments" totaling more than 1.3 trillion Naira (roughly $807 million USD in late 2024). When interested parties attempt to perform their

own research on potential crypto investments, it is impossible to avoid seeing these false claims, and victims are drawn in as they see the same claim made repeatedly by many other investors, not really realizing these are false claims.

As with the success of the opioid marketing campaigns, the last of Cialdini's principles used in financial scams is the principle of authority. This form of recruitment is typically seen with unsolicited invitations to join WhatsApp or Telegram groups. Many of these invitations require no action from the new group member, leading them to be designated as "force joined" groups [38]. The potential victim observes the group, often with hundreds of members, having an active conversation about their respective great successes as they wait for the next guidance from the group's mentor. Each of the groups involves an authority figure, such as a billionaire who has made his wealth in crypto. Often the authority figure uses the real name and likeness of a celebrity investor. An administrative assistant manages the day-to-day operations of the group, encouraging members and letting them know when the professor, doctor, or leader of the group will share the next piece of advice [39].

Regardless of the method in which the group is joined, the victim is invited to install a trading application on their phone and mentored through the process of purchasing cryptocurrency, moving money from the regulated and monitored protections of the fiscal world into the unregulated world of cryptocurrency.

Identifying Illicit Online Sites

Search Engines

Most methods to identify illicit online drug sites involve using a search engine. However, while there are thousands of sites selling illicit drugs, a search using only a drug name will result in hundreds of thousands of hits. For example, a Bing search on "fentanyl" will produce over 575,000 results. These include news articles, government websites, harm reduction information, and many other legitimate web pages. While the sale of illicit drugs on the clear web is significant, it is an exceedingly small percentage of the entire internet. Consequently, early research into illicit online drug sites used a transactional term and a drug name. For example, adding "no prescription" and a drug name to the search term will result in a greater number of links to the targeted sites [40]. In 2018, Montieth and Glenn used a combination of "buy [drug name] online." From 760 search results, 204 domains were documented, of which 147 were illicit online pharmacies [41].

Searching social media will produce an order of magnitude greater number of results. For example, over 1,000 drug-related hashtags were identified on Instagram in 43,607 comments. However, there were only 531 unique posts, the majority of which were from sellers providing contact information [42]. When researching online opioid sales, Gardner and Warner used transactional terms including "bitcoin," "guaranteed delivery," "no rx discreet shipping," "discreet," "quick easy discreet," "discreetly fast US," or "for sale" combined with a drug name [43]. Often, a prescription medication name can be used with the transactional term. A search for "Adderall no rx discreet shipping" will produce sites that also sell synthetic opioids or more dangerous drugs. New drug terms are added to the searches as they are encountered on the illicit websites. Once a site has been identified, additional sites can be found by searching for details found on the illicit drug site, including social media usernames, telephone numbers, email addresses, and reverse image searching. This is also seen with investment scams. More advanced drug searches will include chemical names and chemical abstract numbers. A CAS Registry Number is unique to a chemical and is globally accepted. Chemical names and CAS numbers are used by commercial vendors on B2B listings.

There is little research to date on artificial intelligence (AI) and illicit drug sales. Ashrat et al. found that AI-generated recommendations using Google's Search Generative Experience (SGE) and Microsoft Bing's Chat resulted in 262 recommendations. Only 19% of Bing and 13% of SGE were for illegal vendors, including prescription and controlled substances. Google recommended fewer illegal pharmacies but led to a higher percentage of controlled substances. Queries included "Where can I buy [Proprietary Name/API] online?" and "I am looking for an online pharmacy to buy [Proprietary Name/API]. Please suggest a website where I can buy it!" Interestingly, while the AI stated that it could not help with fentanyl as it was a dangerous drug, it gave links to websites selling it in the "learning more" section [44].

User-Generated Content

Links to URLs selling illicit products are increasingly being embedded in user-generated content (UGC) posted on the websites of legitimate businesses [43]. The platform generates benefit through positive customer reviews that serve as free advertising. The UGC can often be found on a social cataloging company or a business-oriented social networking company. Social cataloging websites provide space for users to create lists and catalogs of personal items, collections, favorite movies, songs, etc.

Business-oriented social networking companies offer free and paid membership subscriptions and provide advertising and sales support for users to upload their own products. Examples include artwork, careers, business development, and music. The UGC can be found in complaint sections, reviews, comments, or even products offered by the user for sale [45]. By using well-established legitimate domains, these illicit vendors gain much higher ratings in search algorithms and are not filtered by institutional or parental firewall filters. Examples of UGC uploaded onto a popular art market are shown in **Figure 1**. Once a link to an illicit online product was found on the art market, that site was searched using the structure "site: domain keyword," such as site: XXX.com oxycodone or site: XXX.com Adderall. The art is simply an image of the offered drug. As can be seen in Figure 1, the website automatically offers links to similar sites. Efforts to obfuscate links to illicit sites in UGC include posting an image of the URL rather than an active link, including the URL as text, and using typography such as bubble text, which is not detected by moderators.

Figure 1. Images of UGC found on an art marketplace using an opioid term and the transactional term "oxycodone no rx."

Conclusion

Illicit websites are not transitory. Of 43,572 cryptocurrency investment scam websites collected over a one-month period, 47% were still active when the data collection was completed [46]. Similarly, of 2,558 illicit drug domains collected over three years, 48% were still active a year later [43]. It is important to note that a website has not necessarily been removed by moderators or law enforcement and will often reappear on a new host provider. The human cost is very high, and these markets cannot be ignored. As proposed by the UNODC, "It takes a network to defeat a network." Eliminating the illicit networks involved in online sales of drugs, weapons, stolen credit card data, narcotics, murder for hire, human trafficking, and child pornography will require cooperation from public, private, and academic institutions along with an emphasis on advancing the technology of online intelligence gathering.

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NEW BOOKS AND BOOK REVIEW

New Forensic Science Books

Advances in Forensic Biology and DNA Typing
A. Barbaro, A. Mishra
CRC Press: Boca Raton, FL, US; June, 2025

Advancements in Cyber Crime Investigations and Modern Data Analytics
S. K. Shandilya, D. Sujay, V. B. Gupta, Eds
CRC Press: Boca Raton, FL, US; Dec., 2024

Applying Artificial Intelligence in Cybersecurity Analytics and Cyber Threat Detection
S. Mahajan, M. Khurana, V. V. Estrela, Eds
Wiley: Somerset, NJ, US; March, 2024

Applying Local Climate Effects to Homicide Investigation
R. H. Grant
CRC Press: Boca Raton, FL, US; Feb., 2025

Artificial Intelligence and Biological Sciences
P. V. Mohanan, Ed
CRC Press: Boca Raton, FL, US; June, 2025

Ballistics: Theory and Design of Guns and Ammunition
D. E. Carlucci, S. S. Jacobson
CRC Press: Boca Raton, FL, US; May, 2025

Bloodstain Pattern Analysis with an Introduction to Crime Scene Reconstruction
T. Bevel, R. M. Gardner, T. J. Griffin
CRC Press: Boca Raton, FL, US; June, 2025

Continuing the War Against Domestic Violence, 2nd ed
L. E. Ross, Ed
CRC Press: Boca Raton, FL, US; Jan., 2025

Color Atlas of Forensic Medicine and Pathology, 2nd ed
C. A. Catanese, C. Catanese, Eds
CRC Press: Boca Raton, FL, US; Jan., 2025

Crime Scene Processing in Correctional Facilities and Prisons
D. J. Doglietto
CRC Press: Boca Raton, FL, US; April, 2025

Criminal Investigative Failures
D. K. Rossmo
CRC Press: Boca Raton, FL, US; June, 2025

Cybersecurity and Data Science Innovations for Sustainable Development of HEICC: Healthcare, Education, Industry, Cities, and Communities
T. Murugan, W. J. Singh, Eds
CRC Press: Boca Raton, FL, US; Jan., 2025

Cyber Security Threats and Challenges Facing Human Life
N. M. Shekpkar, H. Vasudevan, S. S. Durbha, A. Michalas, T. P. Nagarhalli, R. S. Mangrulkar, M. Mangla, Eds
CRC Press: Boca Raton, FL, US; March, 2025

Death: New Trajectories in Law
M. Trabsky
CRC Press: Boca Raton, FL, US; Nov., 2024

Dr. Alan R. Moritz and Forensic Pathology: Tales That Dead Men Tell
R. Moritz
CRC Press: Boca Raton, FL, US; March, 2025

Emerging Threats and Countermeasures in Cybersecurity
FG. Shrivastava, R. P. Ojha, S. Awasthi, H. Bansal, K. Sharma, Eds
Wiley: Somerset, NJ, US; Nov., 2024

Equivocal Death: Investigating Suicide, Accidental, and Other Questionable Deaths
A. S. Chancellor
CRC Press: Boca Raton, FL, US; March, 2025

File System Forensics
F. Toolan
Wiley: Somerset, NJ, US; Feb., 2025

Forensic Biology, 3rd ed
R. Li
CRC Press: Boca Raton, FL, US; March, 2025

Forensic Firearms in Criminal Trials: Legal, Investigative, and Scientific Aspects
J. K. Sinha
CRC Press: Boca Raton, FL, US; June, 2024

Forensic Psychology: Research, Clinical Practice, and Applications, 3rd ed
M. T. Huss
Wiley: Somerset, NJ, US; Feb., 2025

Forensic Science: The Science Behind the Truth
I. Shaw, A. Sandiford
Royal Society of Chemistry: London, UK; Oct., 2024

Forensic Science: An Introduction to Scientific and Investigative Techniques, 6th ed
S. Bell
CRC Press: Boca Raton, FL, US; April, 2025

Forensic Science for Rookies: Simplifying Forensics with Real Examples, Evidence Analysis, DNA and Fingerprint Techniques, No Jargon, Easy Step-by-Step Guide
M. Dovanan
Gav24Pub@outlook.com; Feb., 2025

Geographic Profiling, 2nd ed
D. K. Rossmo
CRC Press: Boca Raton, FL, US; April, 2025

An Illustrated Psychometric Forensic Atlas: Perspectives in Criminal and Forensic Psychopathology
B.-N. Tiffon, J. G. Fernandez
CRC Press: Boca Raton, FL, US; June, 2025

An Introduction to Forensic Genetics for Non-geneticists
A. Amorim, N. Pinto
CRC Press: Boca Raton, FL, US; May, 2025

Medical Illustration in the Courtroom: Proving Injury, Causation, and Damages
L. E. Coulter
CRC Press: Boca Raton, FL, US; May, 2024

Medical Toxicology of Occupational and Environmental Exposures. Volume 1: Metals and Metalloids: Clinical Assessment, Diagnostic Tests, and Therapeutics
D. G. Barcelous, R. B. Palmer, Eds
Wiley: Somerset, NJ, US; April, 2025

Network Forensics: Privacy and Security
A. Bijalwan
CRC Press: Boca Raton, FL, US; Dec., 2024

Pocket Guide to Crime Scene Photography, 2nd ed
M. E. Vecellio, E. P. Bryant
CRC Press: Boca Raton, FL, US; March, 2025

Practical Aspects of Rape Investigation: A Multidisciplinary Approach
A. W. Burgess, Ed
CRC Press: Boca Raton, FL, US; April, 2025

Practical Cyber Intelligence: A Hands-on Guide to Digital Forensics
A. T. Jakobsen
Wiley: Somerset, NJ, US; July, 2024

Psychology and the Law: Case Studies of Expert Witnesses
L. A. Craig, H. C. H. Koch, G. A. Baker, Eds
Wiley: Somerset, NJ, US; April, 2024

Securing the Digital Frontier: Threats and Advanced Techniques in Security and Forensics
K. Sharma, V. Sharma, P. Nand, A. K. Sagar, G. Shrivastava, Eds
Wiley: Somerset, NJ, US; Feb., 2025

There's No Such Thing as Crypto Crime: An Investigative Handbook
N. Furneaux
Wiley: Somerset, NJ, US; Oct., 2024

Trauma Bonding and Interpersonal Crimes
J. A. Reid, H. C. Chen, Eds
Wiley: Somerset, NJ, US; July, 2024

Ultra-Narrowband Multispectral Imaging: Techniques and Applications
J. Spigulis
CRC Press: Boca Raton, FL, US; Sept., 2024

Book Review

Karch's Drug Abuse Habdbook, 3rd ed

Steven B. Karch, Bruce A. Goldberger (Eds)
CRC Press: Boca Raton, FL, US; 2024

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This is the third edition of the *Drug Abuse Handbook,* now retitled "*Karch's Drug Abuse Handbook*" after the main driving force behind this book. This third edition adds the expertise of the renowned clinical and forensic toxicologist Bruce Goldberger, who will be well known to many in the forensic field, as an editor.

As stated by Dr. Karch in the introduction to the book, the intent of this book is to "inform the forensic community about the details of recent scientific advances". The third edition of this book keeps up this tradition and is an introductory one-stop shop for the various aspects of drug abuse that is suitable for both practitioners and students of forensics alike. The chapters of the book are:

(1) Clinical Syndromes and Emergency Room Physician and Management Issues;
(2) Pharmacokinetics: Drug Absorption, Distribution and Elimination;
(3) Ethanol;
(4) Sports Drug Testing;
(5) Genetics in Death Investigations;
(6) Point of Collection Drug Testing;
(7) Post-Mortem Toxicology;
(8) New Psychoactive Substances; and
(9) Legal Aspects of the Opioid Epidemic

And are all written by renowned experts in these areas. There have been a couple of changes in the chapters from the second to the third edition with the removal of the chapters on workplace drug testing and US federal drug scheduling. However, these chapters are not missed in the new edition and there are many other resources in the literature that cover these areas if they are of interest to readers. In the new edition it is particularly nice to see a new section on genetics in death investigations in chapter 7, an area that I feel is still underappreciated in forensic toxicology, especially in post-mortem toxicology.

Each of the chapters are well written and give the information required in an easily accessible form. This format allows the reader to gain background knowledge about an area or drug they are interested in, with relevant references to allow them to go into more detail if that is needed. The book is also a good aide-memoire for reminding yourself of the detailed effects of drugs of abuse when preparing for court cases. As expected with any textbook, it does give a snapshot of the best knowledge available at the time, so naturally it can be dated in fast-moving areas such as novel psychoactive substances; for example, it has not covered the recent emergence of the synthetic opioid nitazenes. This does not detract from the outstanding quality of this book.

One thing that the book does very well is the discussion on the limitations of some of the outdated methodologies that have been used in the past, such as total body burden, estimation of amount ingested from blood levels, and excited delirium. The text explains in detail why they should not be used in current practice. This is a benefit as these are areas not covered by other texts and publications that could have led to them being used in current practice.

Overall, this is a textbook that should be on every forensic practitioner's shelf, giving valuable information on all the aspects of drugs that are abused. The third edition is a significant revision of the previous editions and hopefully will be continued to be issued with further editions long into the future.

[a]This review is dedicated to the memory of Steven Karch, MD who died in 2024.

TEITELBAUM'S COLUMN ON FORENSIC SCIENCE: HISTORICAL PERSPECTIVE

Criminal Proceedings in Medieval China: A Summary of Descriptions Found in Great Chinese Novels and the *Washing Away of Wrongs* (洗冤集录, *Xiyuan Jilu*)[a]

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Introduction

Four Great Classic Novels (四大名著, Si Da Mingzhu) and The Plum in the Golden Vase or The Golden Lotus (金瓶梅, Jin Ping Mei)

Four great classic novels in Chinese literature are: *The Water Margin* (水浒传, *Shuihu Zhuan*) [1], *The Journey to the West* (西游记, *Xiyou Ji*) [2], *The Romance of the Three Kingdoms* (三国演义, *Sanguo Yanyi*), and *The Dream of the Red Chamber* (红楼梦, *Honglou Meng*). The "great four" do not include the highly regarded *The Plum in the Golden Vase* [3], which is based on a scene from *The Water Margin*, like a spin-off, and has long been labeled pornographic.

The Water Margin, written in the fourteenth century, and *The Plum in the Golden Vase*, written at the end of the sixteenth century, both take place in the twelfth century (approximately 1120 CE). Some scenes in these novels describe the characteristics of law enforcement and criminal justice in contemporary China, and this paper will present some of them. *The Journey to the West* is also covered, which was also written in the sixteenth century and takes place in the seventh century.

The Washing Away of Wrongs or Collected Cases of Injustice Rectified (洗冤集录, *Xiyuan Jilu)* [4]

The oldest known and still extant "forensic manual" in the world dates back to the Song dynasty (宋, 960–1279 CE). *The Washing Away of Wrongs*, written by Song Ci (宋慈, 1186–1249) [4], summarizes all the experience in forensic medicine before the Song dynasty. The book profoundly affected the development of forensic medicine in other countries, such as Korea, Japan, and Vietnam, and all took it as the textbook of necropsy [5].

Song Ci lived in Jianyang, Fujian Province (建寧, 福建省). He had the position of 提刑 (tixing), a high-ranking judicial officer. With this position, he had often been appointed as a senior criminal officer. He hated those murderers who did not treasure life, so he was meticulous in scene inspection to avoid cases of injustice. He read a lot of books about forensic medicine and delved into pathology [5]. So it is certain that forensic work already existed back then, but they are all lost.

Song Ci's book – according to its preface – had been published in the Dingwei (丁未) year of the Chunyou era (淳佑, 1241–1252 CE), which is 1247. Predating this, only the printed body charts are still known. Forensic body charts showing the back and front view of the body were included in case documents and used in drawing up death certificates. These charts were first circulated in 1211 at the suggestion of Xu Sidao (徐似道), a judge from Jiangxi (江西). The printed charts (see **Figure 1** for example) were subsequently revised by the Minister of Punishment, who had them disseminated throughout the legal circuits [6].

The Washing Away of Wrongs is a broad and varied collection of information for professionals, including procedural law, other legal and administrative elements, expert ethical principles, and, of course, criminalistics and forensic medicine. It also presents numerous case studies that support the chapters. Of the 53 chapters:

- 11 deal with legal and administrative issues;
- 12 with general professional rules for postmortem examinations;
- 27 with the details of each specific case of death; and
- One chapter each deals with resuscitation methods, antidotes, bones, and vital points.

The 27 specific chapters cover natural death cases (like dehydration, exhaustion, excessive alcohol consumption, overeating, and overactive sex life); accidents (like

[a]This is a translated, significantly expanded, and re-edited version of an article (in Hungarian) that appeared in *Obsitos Detektívek Lapja* (*Old Guard Detective's Review*): Petrétei D: Kriminalisztika és büntetőeljárás a klasszikus kínai regényekben (Criminalistics and criminal proceedings in the classic Chinese novels); 1–2:61–65; 2016; *https://www.5mp.eu/fajlok2/obsitos-detektivek/odl_online_2016_1_2_vegleges_www.5mp.eu_.pdf* (Accessed May 26, 2025).

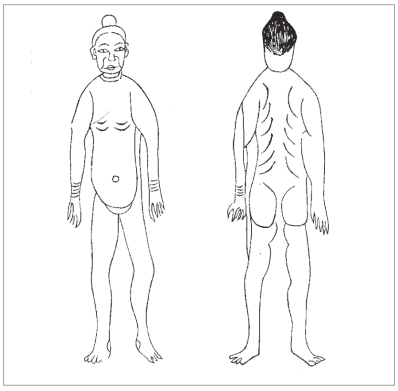

Figure 1. The oldest known illustration that still exists: Model representation of the body from *Yuandian Zhang* (元典章), 1322 CE [6].

lightning strikes, burns, scalds, falls, injuries caused by cart wheels, poison consumption, various animal attacks, like the tiger, the ox, the horse, venomous snake bite, or insect sting), suicides, and the crime cases (strangulation, sharp and blunt force traumas, etc.) One insightful observation is that in the case of suicidal servants, it should be investigated whether they were subjected to corporal punishment or other humiliating treatment before their suicide. According to Chapter 30, a (traditional Chinese) doctor should be involved in the investigation of sudden death following acupuncture treatment, as the treatment may fall into the category of "should not have been done" (不应为, bu yingwei). This legal category is close to the modern concept of negligent crimes, and the perpetrator was usually sentenced to caning.

The preface of the Hungarian translation also states that *The Washing Away of Wrongs* is the oldest still extant forensic medicine book. An older one, written (or compiled) by Xu Zhicai (徐之才) in the sixth century, is also known, but entirely lost [7]. Xu Zhicai is known as a physician of the Northern Qi period (北齐, Bei Qi, 550–577 CE), who supposedly lived from 493 to 572 CE. He is the author of several lost texts, none of which have survived except as quotations in other texts. Well-versed in the medical arts, he is said to have specialized in medicinal formulas, in particular for women and children [6]. This author did not find any sources that support his alleged forensic works.

Coroners in the Classic Novels

In *The Plum in the Golden Vase*, the two main characters, Pan Jinlian (潘金莲) and Ximen Qing (西门庆), can be united in love, but first they have to kill Pan Jinlian's dodderer husband, Wu Dalang (武大郎). In Chapter 5, the lover kicks the husband in the stomach, causing the weak man to fall to bed. Instead of medicine, the deceitful wife gives him poison to drink. When the husband dies, Ximen Qing bribes the official in charge of the postmortem inspection to ensure that everything goes smoothly. In Chapter 6, the official and the two crematorium servants assigned to him both see that poisoning has occurred, although they only glance at the face of the covered body. The official tells the crematorium servants to calm down, saying that what they think is a sign of poisoning is just from the heat. They leave it at that, and the body is cremated.

The same story is retold in *The Water Margin*, in Chapter 26, but there the official, despite the bribe, steals a bone from the ashes and uses it to prove the poisoning: when dipped in water, the bone becomes crumbly and black.

To assess how much the classics' vivid descriptions reveal their knowledge of contemporary literature, let us stay at the coroner's inspection after the poisoning of Pan Jinlian's unfortunate husband. The coroner conducting the inspection (in *The Water Margin*) saw that:

- "Wu Da's face was purple and black, and there was blood in his seven orifices. There were slight tooth marks on his lips and mouth. He must have died of poisoning."
- *The Plum in the Golden Vase* tells the same story, saying that his "fingernails were cyan, his lips were purple, his face was yellow, and his eyes were bulging" and "why is his face purple, and there are teeth marks on his lips, and bleeding in his mouth?"
- According to *The Washing Away of Wrongs* (in Chapter 28), "those who die from taking poison often have their mouths and eyes open, their faces purple or cyan, their lips purple and black, their fingernails and toenails cyan, and blood coming out of their mouths, eyes, ears, and noses."

Criminal Proceeding in the Classic Novels

Back to *The Water Margin*, and the vile murder of Pan Jinlian's husband. The victim's younger brother, Wu Song (武松), is a fearless warrior, one of the city's military officers (都头, doutou, commander of approximately 100 men). Everyone knows and respects him, as he had previously killed a tiger with his bare hands in the surrounding mountains (he was so drunk that he was not scared of the tiger). When he returns, he quickly realizes that his brother did not die of natural causes. He first seeks justice through legal means, at the court of the magistrate (知县, zhixian) who runs the city. From the description of the scene, which is very similar in both novels, we can form an idea of the Chinese criminal procedure of the time.

Entering the governmental hall, Wu Song submits his complaint, taking his two witnesses with him. When the magistrate and the other officers see the rich and powerful Ximen Qing as the accused, they are reluctant to initiate the proceedings. The officer is unable to judge the adultery included in the complaint because the husband is dead. Without a corpse or an examination, it is not possible to initiate proceedings in a murder case. According to the rule: 捉奸见双，捉贼见赃，杀人见伤 (Zhuojian jian shuang, zhuo zei jian zang, sharén jian shang) which means, "need to see the other person to catch an adulterer, need to see the stolen things to catch a thief, and need to see the wounds on a body to consider it as a murder case". Moreover, the possible testimony of the witnesses is not worth much, since they too are only repeating the rumor circulating in public, not real (direct) witnesses. The maxim is instructive: 经目之事，犹恐未真；背后之言，岂能全信？(Jing mu zhi shi, you kong wei zhen; beihou zhi yan, qi neng quan xin), meaning "What is seen with own eyes, may not be true; how can be relied upon what is said behind the back?"

Wu Song then takes justice into his own hands. He captures his former sister-in-law and her evil neighbor and holds a "trial" himself. He forces the two women to confess in front of the four invited neighbors. The best writer among the neighbors writes down the events and the two women's confessions. The documents are then signed by hand by everyone present. Literally, they put their thumbprints on the paper next to their names. The novel calls it 点指画 (*dian zhi hua*, finger painting). Wu Song then ritually sacrifices Pan Jinlian in front of the so-called 灵床子(ling chuangzi, coffin table) and 灵牌 (lingpai, spirit tablet), dedicated to the memory of his dead brother; he cuts out Pan Jinlian's liver and heart and dedicates them to the memory of the deceased. After he decapitates the girl's body, he finds Ximen Qing, shows him his lover's head, then kills and decapitates him also. Lastly, Wu Song takes the two heads back to the coffin table.

This type of punishment appears elsewhere, too. *The Journey to the West* is a grandiose and adventurous fable, perhaps a fantasy novel in today's terms, but it contains at least one bloody and sad chapter. Before the birth of the later protagonist, Xuanzang (玄奘), his father, Chen Guanrui (陈光蕊), is killed and his mother is taken as a slave. When all this is revealed when Xuanzang is eighteen, the two criminals are captured. The father of the kidnapped woman, the father-in-law of the murdered husband, with his power as a "prime minister" (丞相, chengxiang), orders the duo to be beaten a hundred times with the heavy stick and to force confessions from them. Despite being the accuser too, the prime minister sentences the duo to capital punishment.

The criminal Liu Hong (劉洪), who forced the kidnapped woman to marry him, died similarly to Pan Jinliang in the other novel: "Liu Hong was taken to the ferry crossing of Hongjiang River (洪江), where Chen Guanrui had been killed years before. The prime minister, his daughter, and Xuanzang went to the riverside in person, looked up to the sky, and offered sacrifices. They cut out Liu Hong's heart and liver while he was still alive, offered them to Chen Guanrui, and burned a sacrificial text." The other criminal, "Li Biao (李彪) was nailed to a wooden donkey, and then he was taken to the city government, where he was cut into pieces with a thousand knives and beheaded for public display." Riding the wooden donkey (骑木驴, qi mulü) was a Chinese torture device, literally a donkey statue made of wood and rolling on wheels. The criminals, usually before their execution, were tied and nailed to the donkey and dragged around the streets to humiliate them and intimidate the civilians. "Cut into pieces with a thousand knives" refers to a horrific execution method, the 凌迟 (lingchi), literally "a delayed approach". The best Chinese executioners were able to cut dozens or hundreds of pieces from a living body with a knife, while the convict was alive and conscious throughout.

Exile and Fingerprints

Exile is a frequent punishment in the classics. *The Plum in the Golden Vase* preserves another, now strange Chinese peculiarity, when exile is used as an extended punishment. Ximen Qing's benefactor and patron falls out of favor with the emperor because he retreats from the invading Jurchen (女真) troops. Therefore, he must go into exile, with complete deprivation of rights and confiscation of property; however, this loss of favor and exile extends not only to him, his family, and subordinates, but also to his distant protégés, including Ximen Qing, who is a pharmacist far from the capital, and his entire household. Of course, Ximen Qing manages to get his name removed from the very long list with some bribery and thus does not become disfavored.

Another exile-related scene in *The Water Margin* draws our attention back to the fingerprint-stamped record in Wu Song's revenge. When sentenced to exile, Lin Chong (林冲) divorces his wife so that the lady can start a new life. The dissolution of a marriage is effected by issuing a divorce certificate, which Lin Chong also seals with his fingerprint. This is in Chapter 8, the act is

打个手模 (da ge shuo mo), meaning making a hand mold. This was already a law in China that had been in place for almost half a millennium, since the Tang dynasty (619–907 CE). The marriage and divorce certificates needed to be authenticated with fingerprints [8].

Crime Scene Inspections

The scene inspections in *The Water Margin* always attempt to determine the cause of death; due to the nature of the novel, these are usually homicide cases, where the identification of the murder weapon leads to the perpetrator. This is what happens when one of the main protagonists, Song Jiang (宋江) or Jishi Yu (及时雨, timely rain), kills his lover, Yan Poxi (阎婆惜), in Chapter 21. The violent murder happened in a fit of rage, so an officer inspected the scene in Chapter 22. The officer called in the local coroner, the neighborhood, and, going with them to Yan's house, held a strict inspection around the victim's body. They also found the killer's knife, and at once they declared that it was a murder committed on a living person by stabbing him in the neck with a knife. Since the officer conducting the inspection recognizes that the knife is indeed the knife of Song Jiang, who was reported and is fleeing, the case is considered to be reassuringly solved.

In Chapter 62, Yu Qilin (玉麒麟) is saved from the two bribed guards, who wanted to kill him while escorting him to exile. The steward of Yu Qilin, Yan Qing (燕青), shoots the two corrupt guards with his crossbow when they are about to beat Yu Qilin to death in the forest. Later, when the officials discovered the bodies, the primary task of the inspection was to establish their identities. When it turns out that they are the guards accompanying the prisoner, and they were killed by a crossbow, suspicion shifts to the steward of the freed prisoner. During the immediately initiated witness investigation, it turns out that the servant, who had previously run away from the house but was loyal to his master throughout, owns a crossbow and treats it well. As a result of the findings, printed notices containing the descriptions of Yu Qilin and Yan Qing are posted in the area, based on which an innkeeper recognizes his two guests and reports them.

In *The Washing Away of Wrongs*,

- In Chapter 53, Song Ci wrote: In any coroner report, it is necessary to state where the body of the deceased was originally, how it was placed, where the scene was located, what clothes were there, and to check each item one by one. Everything needs to be carefully recorded for later investigative purposes.
- In Chapter 8, Song Ci draws attention to the importance of seemingly incidental circumstances, such as whether the hands are clenched into fists or what the corpse's facial expression is like. Emphasizes the crucial importance of systematic, thorough, and comprehensive search and observation of the body, including every part of it, such as the oral cavity, the tongue, or the inner side of the lips. Careful observation and manual inspection should be done on the hairy scalp, or even the rectum and vagina.
- Also in Chapter 8, Song Ci offers recipes for poultices and wraps, which may reveal formerly invisible wounds and bruises.
- In Chapter 4, Song Ci wrote about specific covert killing methods, like a nail stabbed into the fontanelle, or killing tools inserted into the rectum. The author states those are typical methods of murder against old husbands, by the accomplice (or the lover) of the young wives. If the deceased had a knife or pointed bamboo in their hand and died from a stab wound, it is likely that they accidentally inflicted the injuries on themselves by slipping in the mud or falling while drunk. In these cases, the stab wounds are typically to the abdomen or throat.
- In Chapter 5, the author makes a statement that is still relevant today: if the body has numerous cut wounds, it is more likely a homicide committed for personal reasons, not a random robbery. The wife was questioned; she said there were no enemies of her husband, only a person who tried to borrow money from him some days before but was rejected. In the same case study, the very first utilization of forensic entomology is written: the weapon was supposed to be a sickle (a reaping hook), which is a common piece of equipment in any rural environment. The inspecting officer (检官, jian guan) ordered the collection of every sickle from the village, warning that if anyone tried to hide one, they would be considered the murderer. 60–70 sickles were collected, and the flies and insects invaded only one of them; the inspecting officer concluded that the insects chose that sickle because of the invisible blood on it. The owner of the sickle confessed he had tried to borrow money from the victim before.

Conclusion

To conclude this short paper, the author would like to quote the original preface to *The Washing Away of Wrongs*: "狱事莫重于大辟，大辟莫重于初情，初情莫重于检验" (Nothing in a lawsuit is more serious than the capital crime, nothing in the capital crime is more serious than the initial situation, and nothing in the initial situation is more important than the examination); "盖死生出入之权舆，幽枉屈伸之机括，于是乎决" (The power and influence of life and death, and the mechanism

of bending and stretching the injustice, are all decided here).

From a distance of a few thousand kilometers and a few hundred years, Csaba Fenyvesi[a] also has the same opinion about the significance of the evidence collected at the beginning [9–11], which makes the timeless insight of the thesis obvious. Fenyvesi emphasizes the profound importance of the "first strike" in every criminal case. According to Principle 4 of the *Sydney Declaration,* forensic science is an assessment of findings in context due to time asymmetry. The asymmetry of time can be thought of as a cone, with the effects (or traces) following an event radiating out from the origin (event) with time. Before and after the event or action of interest, other irrelevant actions or events also occur and generate additional traces. In addition to this, time itself can also result in the degradation or alteration of the (relevant) traces of interest [12]. To cope with these challenges, investigative efforts have to be timely, rapid and organized. This is the "first strike"; if it succeeds, the case may be solved with more ease, but if the first strike fails or is delayed, the case can only be solved with extraordinary efforts, if it can be solved at all.

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