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

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

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Δ^8-Tetrahydrocannabinol: Another Cannabinoid of Rising Interest and Concern

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By one account [1], the term cannabinoid comprises all ligands of the cannabinoid receptor and related compounds including endogenous ligands of the receptors and a large number of synthetic cannabinoid analogues. Usually, the primary psychoactive component of marijuana is considered to be Δ^9-THC (Δ^9-tetrahydrocannabinoid; **Structure 1**). Another psychoactive component, Δ^8-THC (Δ^8-tetrahydrocannabinol; **Structure 2**), and CBD (cannabidiol; **Structure 3**), which has no psychoactivity, also may appear in small amounts in marijuana. The placement of Δ^9-THC, Δ^8-THC, and CBD in the synthetic cascade for cannabinoids [2] found in *cannabis* is shown in **Figure 1** [3].

Recently, Δ^8-THC is being detected more and more in drug testing programs with alarming concerns [4,5]. Its occurrences and causes of concern are further elaborated in the following sections.

Hemp and the Hemp Farming Act of 2018

Hemp, or industrial hemp, is a botanical class of *Cannabis sativa* cultivars grown specifically for industrial or medicinal use. Hemp can be used to make a wide range of products [6]. The Hemp Farming Act of 2018 [7] legalized industrial hemp that contains no more than 0.3% Δ^9-THC (the major psychoactive component of marijuana [8]) by removing it from Schedule I of the Controlled Substances Act. Even though industrial hemp contains a minimal amount of Δ^9-THC, some varieties of hemp also can contain small amounts of Δ^8-THC, which has about 50–60% of the psychoactivity of Δ^9-THC [9,10], and CBD, which has no psychoactivity [11].

Compounds/Market Products of Primary Interest

Δ^9-Tetrahydrocannabinol. Δ^9-THC is known to be the most psychoactive component of marijuana [8]. Amounts of Δ^9-THC in marijuana can vary from trace to 30% by weight. In appropriate oral or smoked doses, the use of marijuana can produce temporal distortion, sedation, and euphoria. Laboratory analysis can be used to produce a known dose of Δ^9-THC and eliminate unwanted or undesirable contaminants (e.g., pesticides). This compound has been one of the most concerning drugs and has been extensively studied and reported.

Δ^8-Tetrahydrocannabinol. As stated above, Δ^8-THC has about 50–60% of the psychoactivity of the Δ^9-isomer that is the principle psychoactive component of marijuana. Thus, Δ^8-THC can provide most of the desirable effects of marijuana simply by adjusting the dose. However, the amount of Δ^8-THC varies in different species of *C. sativa*. Thus, the starting point at which adjusting dosage begins probably will be unknown. The amounts of unknown, and possibly undesirable, components also may vary [4]. Replacing the illegal Δ^9-THC with Δ^8-THC makes the amount of Δ^8-THC in a product such as the one in **Figure 2** still unknown unless proved by a laboratory analysis. Additionally, the potentially undesirable components of the Δ^8-THC product are unknown both qualitatively and quantitatively, making product safety difficult to assess.

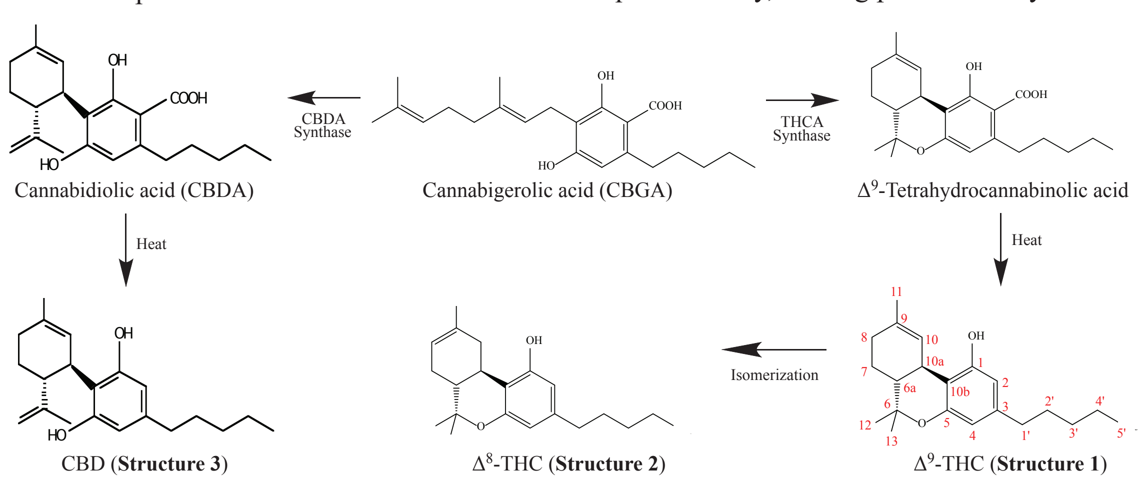

Figure 1. Natural occurrence of Δ^9-THC, Δ^8-THC, and CBD (dibenzopyran numbering system) [3].

Figure 2. Δ^8-THC flower.

A photograph of a marijuana flower that allegedly contains Δ^8-THC is presented in Figure 2. It is notable that the amount of Δ^8-THC in the product is not stated on the product's container.

It is difficult to ascertain the market and demand for Δ^8-THC due to purity issues associated with lack of regulation and sale of material that generally has not received a laboratory analysis for Δ^8-THC. However, a retrospective analysis by one large laboratory produced the positive trend presented in **Table 1** [12].

Table 1. Trend of Δ^8-THC found in connection with Δ^9-THC-positive urine samples

Time period	Containing substantial Δ^8-THC (%)
March 2020	4
September 2020	8
March 2021	18
July 2021	19.9

Cannabidiol. Cannabidiol bears a strong structural resemblance to both Δ^8- and Δ^9-THC. Indeed, by moving the proton on the oxygen at position 5 to the carbon at position 6, Δ^8-THC (which can further isomerize to Δ^9-THC) is created. Transfer of the proton requires heat and acid [13].

An example of commercial CBD-infused candy is shown in **Figure 3**. It appears that the amount of acid required to convert CBD into Δ^8-THC at normal body temperature is insufficient in the human gastrointestinal tract. Since it is known that CBD [13] can be converted into Δ^8-THC and Δ^9-THC by subjecting it to heat and acid, it might be possible for the same phenomenon to occur during the normal transit of CBD through the human gut. However, it appears that the normal oral transit of CBD does not result in the production of toxic degradation products of cannabinol such as Δ^8-THC and Δ^9-THC [14–18].

Figure 3. Cannabidiol gummies and stated contents.

Although it appears to be difficult to assess the Δ^8-THC market, a fair amount of information exists on CBD. In the past few years, the CBD industry's value may be visualized as shown in **Table 2** [13].

Table 2. Increasing value of CBD by years

Year	Value (dollars)
2016	170 million
2023	Several billion

Analytical Issues in Forensic Toxicology

The presence of Δ^8-THC might create an interference in an analytical mixture that contains both Δ^8-THC and Δ^9-THC when it is desirable to quantify either psychoactive material or both. If conditions in the analytical mixture are such that Δ^9-THC can isomerize to Δ^8-THC or the reverse can occur, an erroneous answer will be obtained for both isomers. Likewise, if analytical conditions are such that CBD can cyclize to a mixture of Δ^8-THC and Δ^9-THC, then erroneously high answers for Δ^8-THC and Δ^9-THC will be obtained if CBD is present. Strong acid and heat can have important effects on reaction mixtures containing Δ^8-THC and Δ^9-THC, especially when CBD also is present. Several examples where changing chromatographic apparatus/equipment was useful to obtain an accurate analytical outcome exist [19].

The detection of Δ^8-THC in a biological fluid such as urine should have two phases. In the first or initial testing phase, samples that are presumptively positive are separated from negative samples. In the second or confirmatory phase, samples are determined chemically to be either positive or negative. Using 11 urine samples spiked with Δ^8-THC, Δ^9-THC, or both; confirmatory and initial testing both were performed on all samples [20]. The antibody used for initial testing was essentially 100% crossreactive toward Δ^8-THC-COOH and Δ^9-THC-COOH. On the other hand, in almost all cases examined, the derivatized Δ^8-isomer could be resolved from the Δ^9-isomer, resulting in a successful quantification of each isomer.

It was of paramount importance to develop a method for the analysis of cannabinoids in oral fluid that would eliminate the potential conversion of CBD to Δ^8- and/or Δ^9-THC in silico. Coulter and Wagner [21] did just that by employing a Cerex Polychrom column instead of Trace-N. The oral fluid method developed by these authors completely eliminated any in silico conversion of CBD to Δ^8-THC and/or Δ^9-THC.

In a study by Lin et al. [19], confirmatory methodology for LC-MS/MS determination, CBD did not convert to THC in Quantisal® devices at 22° or 4° C in 14 days. CBD, Δ^9-THC, and Δ^8-THC did not convert to other cannabinoids in the study. Based on quantifiable study results, the confirmatory method did not allow confusion between formed and originally present Δ^9-THC, Δ^8-THC, and CBD.

Concluding Remarks

Although it would seem that the Hemp Farming Act exempted several key psychoactive components of marijuana (Δ^8-THC), there are limitations. CBD is itself nonpsychoactive. Thus, infusing a gummy candy product with CBD as shown above yields a candy that is infused with a nonpsychoactive material. It appears that the amount of acid required to convert CBD into Δ^8-THC at normal body temperature is insufficient in the human gastrointestinal tract. Thus, oral consumption of CBD does not result in the internal production of Δ^8- and Δ^9-THC [14–18]. Likewise, the appearance of **Δ**^{8}-THC in different *Cannabis spp* is highly variable and may not manifest itself at all. The presence of undesirable byproducts in a product that allegedly contains **Δ**^{8}-THC is highly variable and their effects are (at the time of this writing) unknown. Validated analytical methodology that precludes in silico conversion of one cannabinoid such as CBD to another such as **Δ**^{8}-THC and/or **Δ**^{9}-THC is essential for unambiguous interpretation of results from material that contains Δ^8-THC and other materials that may convert to other cannabinoids; such methodology is thus essential to meet any regulatory requirements.

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Upcoming Events

Current Trends Symposium on Forensics & Forensic Toxicology: Current Trends in Seized Drug Analysis
(*https://forensiceducation.cfsre.org/product?catalog=2022_Current_Trends_in_Seized_Drug_Analysis_Symposium*)
Jan. 24–28, 2022; Virtual event
The Center for Forensic Science Research & Education
Willow Grove, PA, US

TIAFT 2021: 58th Annual Meeting of the International Association of Forensic Toxicologists (Around the World in 80 Talks)
(*www.tiaft.org/tiaft-annual-meeting.html*)
Feb. 1–3, 2022; Virtual event

Cannabis Science Conference West
(*https://www.cannabissciencecconference.com/*)
Feb. 2–4, 2022; Long Beach Convention & Entertainment Center
Long Beach, CA

2nd International Congress on Clinical Trials on Cannabis (*https://ct-cann.com/*)
Feb. 16–17, 2022; Hilton London Canary Wharf
London, UK

American Academy of Forensic Sciences — 74th Annual Meeting
(*https://www.aafs.org/*)
Feb. 21–26, 2022; Seattle Convention Center; Hybrid
Seattle, WA, US

American Society of Forensic Odontology — Annual Meeting 2022
(*http://asfo.org/courses/asfo-annual-meeting-2022-seattle-wa/*)
Feb. 22, 2022; Motiff Hotel
Seattle, WA, US

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

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

DATIA 2022 — Annual Meeting of the Drug and Alcohol Testing Industry Association
(*https://datia.memberclicks.net/*)
March 30–April 5, 2022; Omni Louisville Hotel
Louisville, KY, US

California Association of Criminalists — Spring Seminar
(*cacnews.org/events/seminar/seminarcurrent.shtml*)
April 11–15, 2022; Los Angeles County Sheriff's Department of Crime Laboratory
Long Beach, CA, US

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

Southern Association of Forensic Scientists 2022 Annual Meeting
(*https://safs1966.org/annual-meeting/*)
April 25–29, 2022; Chattanoogan Hotel
Chattanooga, TN, US

Mid-Atlantic Association of Forensic Scientists 2022 Annual Meeting
(*https://www.maafs.org/annual-meeting*)
May 10–13, 2022; Marriott at City Center
Newport News, VA, US

International Association of Chiefs of Police 2022
(*https://www.theiacpconference.org/*)
May 24–26, 2022; Wisconsin Center
Milwaukee, WI, US

The Association of Firearm and Tool Mark Examiners — 53rd Annual Training Seminar
(*https://afte.org/meetings/annual-seminars*)
May 28–June 6, 2022; Marriott Marquis
Atlanta, GA, US

9th European Academy of Forensic Science Conference 2022 (*https://www.eafs2022.eu*)
May 30–June 3, 2022; Stockholm City Conf. Centre
Stockholm, Sweden

Society of Hair Testing-Gruppo Tossicologi Forensi Italiani-Joint Meeting in Verona 2022
(*https://www.soht.org/soht-gtfi-joint-meeting-in-verona-2022*)
June 8–10, 2022; University of Verona; Hybrid
Verona, Italy

70th ASMS Conference on Mass Spectrometry and Allied Topics
(*https://asms.org/conferences/annual-conference*)
June 5–9, 2022; Minneapolis Convention Center
Minneapolis, MN, US

American Psychiatric Association — Annual Meeting
(*https://www.psychiatry.org/psychiatrists/meetings/annual-meeting*)
June 7–10, 2022; Ernest N. Morial Convention Center
New Orlands, LA, US

Forensic Analysis of Human DNA — Gordon Research Conference
(*https://www.grc.org/forensic-analysis-of-human-dna-conference/2022/*)
June 19–24, 2022; Mount Snow
West Dover, VT, US

2022 International Association of Bloodstain Analysis European Conference
(*https://www.iabpa.org/2022_european_conference.php*)
June 27–July 1, 2022; University of West London
West London, UK

International Association for Identification — 106th Educational Conference (*https://www.theiai.org/*)
July 31–Aug. 6, 2022; CHI Health Convention Center
Omaha, NE, US

The American Society of Questioned Document Examiners 2022 Annual Meeting (*http://www.asqde.org/*)
Aug. 15–17, 2022; San Antonio Hyatt Regency
Riverwalk Hotel
San Antonio, TX, US

IACP International Conference on Impaired Driving and Traffic Safety
(*https://www.theiacp.org/IDTSconference*)
Aug. 21–23, 2022; Grand Hyatt San Antonio
San Antonio, TX, US

TIAFT 59th Annual Meeting of the International Association of Forensic Toxicologists
(*https://www.versaillespalaisdescongres.com/en/programme/*)
Sept. 5–8, 2022; Versailles Palais des Congrés
Versailles, France

25th Symposium of the Australia and New Zealand Forensic Science Society (*https://www.anzfss2022.com/*)
Sept. 11–15, 2022; Brisbane Convention and
Exhibition Centre
Brisbane, Australia

20th International Congress of Therapeutical Drug Monitoring and Clinical Toxicology
(*https://www.iatdmct2022.org/*)
Sept. 18–19, 2022; Clarion Congress Hotel
Prague, Czech Republic

IFDAT 2022 — International Forum for Drug and Alcohol Testing (*https://www.ifdat.com*)
Sept. 18–20, 2022; Imlauer Hotel Pitter
Salzburg, Austria

2022 International Conference on Forensic Nursing Science and Practice
(*https://www.forensicnurses.org/page/2022AnnualConference*)
Sept. 28–Oct. 1, 2022; Sheraton Dallas
Dallas, TX, US

Southwestern Association of Forensic Scientists — 44th Annual Conference (*http://swafs.us/*)
Oct. 2–6, 2022; M Resort Spa Casino
Henderson, NV, US

SCIX 2022 — Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies
(*https://facss.org/event-3326055*)
Oct. 2–7, 2022; Cincinnati Marriott at River Center
Covington, KY, US

National Association of Medical Examiners
(*https://www.emedevents.com/c/medical-conferences-2022/national-association-of-medical-examiners-name-2022-annual-meeting*)
Oct. 14–18, 2022; Fairmont Dallas
Dallas, TX, US

Northeastern Association of Forensic Scientists — Annual Conference
(*https://www.neafs.org/additional-annual-meetings*)
Oct. 17–21, 2022; Conference & Event Center Niagara Falls
Niagara Falls, NY, US

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

2022 International Association of Bloodstain Analysis Annual Conference
(*https://www.iabpa.org/2022_annual_conference.php*)
Oct. 24–28, 2022; Dana Hotel on Mission Bay
San Diego, CA, US

Society of Forensic Toxicologists — Annual Meeting
(*https://soft-tox.org/meeting*)
Oct. 30–Nov. 4, 2022; Huntington Convention Center
Cleveland, OH, US

ISHI 33: International Symposium on Human Identification
(*https://www.ishinews.com//*)
Oct. 31–Nov. 3, 2022; Gaylord National Harbor
Washington, DC, US

3rd International Caparica Conference in Translational Forensics 2022
(*https://www.forensics2022.com*)
Nov. 14–16, 2022; Hotel dos Capuchos
Caparica, Portugal

American Academy of Forensic Sciences — 75th Annual Meeting
(*https://www.aafs.org/*)
Feb. 13–18, 2023; Rosen Shingle Creek
Orlando, FL, US

ADVANCING THE PRACTICE OF FORENSIC SCIENCE IN THE US — UPDATE

Advancing the Practice of Forensic Science in the United States — Practitioners' Efforts

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Initially conceived as an extension/tool of the criminal investigation process, forensic science is now a fully developed discipline in the United States. Practitioners have been engaged in promoting and continuously improving efforts to bolster the rigor within forensic science for decades, especially since the publication of the 2009 National Research Council (NCR) report, *Strengthening Forensic Science in the United States: A Path Forward* [1], which highlighted several weaknesses in forensic science. Listed below are some specific examples that help verify this development:

- Numerous national/regional as well as scientific area-based forensic science organizations (**Table 1**) have been established and are fully functional — with most of them holding annual conferences to promote findings of foundational and applied research either within a specific forensic science discipline or multidisciplinary context. A few of the organizations publish journals;
- More than 300 forensic science-related educational programs, offering degrees at various levels, have been founded throughout the nation's colleges/universities [2], accompanied by the establishment of an accreditation program operated under the auspices of the American Academy of Forensic Sciences (AAFS) [3]; and
- As summarized in the "Forensics Goes from TWGs to SWGs to OSAC" section of a report by Howe et al. [4], very significant efforts toward advancing the practice of forensic science in the United States have been made by the nation's forensic science practitioners working in various evidence categories to create draft documents to forward to Standards Developing Organizations (SDOs) to publish as voluntary consensus-based forensic science standards and best practices.

Table 1. Forensic science professional organizations in the United States

Organization	Website
Region-Based	
• American Academy of Forensic Sciences[a,b]	*https://www.aafs.org*
• California Association of Criminalists[c]	*https://www.cacnews.org*
• Mid-Atlantic Association of Forensic Scientists[a]	*https://www.maafs.org*
• Midwest Association for Toxicology & Therapeutic Drug Monitoring[a]	*http://www.midwesttox.org/*
• Midwestern Association of Forensic Scientists[a]	*https://www.mafs.net/*
• New Jersey Association of Forensic Scientists[a]	*https://www.njafs.org/*
• Northeastern Association of Forensic Scientists[a]	*https://www.neafs.org*
• Northwest Association of Forensic Scientists[a]	*http://nwafs.org/wordpress/*
• Southern Association of Forensic Scientists[a]	*https://safs1966.org*
• Southern California Association of Fingerprint Officers[a]	*http://www.scafo.org*
• Southwestern Association of Forensic Document Examiners[a]	*http://www.swafde.org/*
• Southwestern Association of Toxicologists[c]	*http://www.sat-tox.org/*
• Southwestern Association of Forensic Scientists[a]	*http://swafs.us/*
Scientific Area-Based	
• American Society of Crime Laboratory Directors[a]	*https://www.ascld.org*
• American Society of Forensic Odontology[a]	*https://asfo.org/*
• American Society of Questioned Document Examiners[a,d]	*http://www.asqde.org/*
• American Society of Trace Evidence Examiners[e]	*https://www.asteetrace.org/*
• Association of Firearm and Tool Mark Examiners[a]	*https://afte.org*
• Association of Forensic DNA Analysts and Administrators[a]	*https://afdaa.org/2013/*
• California Association of Crime Laboratory Directors[a]	*http://cacld.net/*
• Consortium of Forensic Science Organizations	*http://www.thecfso.org/*
• Society of Forensic Anthropologists	*https://sites.google.com/site/forensicanthropologysofa/*
• Society of Forensic Toxicologists[a]	*https://soft-tox.org*
• National Association of Medical Examiners[a,f]	*https://name.memberclicks.net/*

[a] These organizations hold annual conference/meeting/seminar.
[b] Official publication: *Journal of Forensic Sciences*.
[c] These organizations hold semiannual meetings.
[d] Official publication: *The Journal of the American Society of Questioned Document Examiners*.
[e] Official publication: *The Journal of the American Society of Trace Evidence Examiners*.
[f] Official publication: *The American Journal of Forensic Medicine and Pathology*.

The purpose of this report is to highlight several accomplishments in which practitioners are improving forensic science.

Professional Organizations

Membership in a professional organization is a critical component in keeping abreast of current research and information used to strengthen forensic science. Most forensic professionals are members of at least one national or regional forensic science professional organization, whose purpose is to promote ethical principles, foster collaboration, engage in and disseminate research, and provide education through scientific sessions, lectures, webinars, forums, scientific journals, and newsletters. These platforms bring together a wide audience, including forensic practitioners, criminal justice, medical, and legal professionals, academic researchers, and policy stakeholders to promote and advance research and communicate current activities in the field. Because sustained progress in forensic science research is critical for advancing public safety and the administration of justice [5], these opportunities are valued by practitioners.

Forensic Science Education

The interest in forensic science grew in response to media coverage of high-profile cases and the rise in television crime dramas in the early 2000s. In response, a proliferation of academic programs emerged. It was soon realized, however, that most graduates lacked the appropriate scientific background to prepare them to work in a crime lab. Crime lab directors noted inconsistencies among curricula of forensic science programs [6]. To address the growing problem, NIJ created a Technical Working Group for Education and Training in Forensic Science (TWGED) to recommend the training needs of the profession to include accreditation of academic programs and national standards for education [6]. The guidelines were published in 2004. In response, the AAFS created the Forensic Education Programs Accreditation Commission (FEPAC) to develop standards and requirements for formal evaluation and accreditation of college-level forensic science programs [7]. FEPAC accredits forensic science programs that lead to a bachelor's or master's degree in forensic science or in a natural or computer science with a forensic science concentration [4]. FEPAC accredited its first university program in 2004 [7]. Accreditation has matured to include a review of curriculum, faculty contributions to the forensic community, and job placement of students postgraduation, as well as other aspects [7]. FEPAC currently accredits 49 university baccalaureate and graduate programs [3].

Practitioners' Initiatives

Technical Working Groups (TWGs). Various jurisprudences around the world have long been utilizing individuals with special knowledge or skills to assist in their legal proceedings. As this process moves forward, the practice of these "forensic scientists", like everything else, requires advanced methodologies and accountabilities. Thus, under the sponsorship of the FBI (US Federal Bureau of Investigation) Laboratory, forensic scientists working in various evidence categories have formed respective "Technical Working Groups" (TWGs) to:

> *"develop and standardize protocols and analytical practices"* [8]

TWGs were created for the short term and usually had a single deliverable, such as a guideline on a specific topic [9]. The original TWG, the Technical Working Group on DNA Analysis Methods (TWGDAM) first convened in November 1988. The DNA Identification Act of 1994 [10] authorized the FBI to formally establish the Combined DNA Index System (CODIS) and authorized the creation of the Federal DNA Advisory Board. The legislation adopted the TWGDA guidelines, thus paving the way for additional TWG documents [11].

In a 1997 report [8], the FBI Laboratory reported: "technical working groups for DNA, latent fingerprints and paints, polymers and fibers have been formed and have already resulted in improved procedures and practices". At the time, plans had also been made on establishing additional working groups on the analysis of shoe prints, handwriting, tire treads, and bombing and explosives.

Taking TWGDAM as an example to illustrate the operation of these working groups: "[t]he first meeting consisted of 31 scientists representing 16 forensic laboratories in the United States and Canada and two research institutions. … Over the years, several subcommittees have operated to bring recommendations … TWGDAM issued guidelines for quality assurance in DNA analysis in 1989, 1991, and 1995. … The 1995 'Guidelines for a Quality Assurance Program for DNA Analysis' served as the de facto standard for forensic DNA testing" [12].

All TWGs were eventually disbanded or converted to Scientific Working Groups (SWGs) as further described in the next sections.

Scientific Working Groups (SWGs). "[G]roups of experts in a particular forensic discipline have evolved into bodies that develop standards, best practices, and protocols. They began as Technical Working Groups (TWGs) in the early1990s. In 1999, the name was changed to Scientific Working Groups (SWGs) in an attempt to distinguish the

FBI supported long-term working groups from the US National Institute of Justice (NIJ) TWGs that were of short duration and usually had a single deliverable, such as a guidebook on a specific topic. SWGs are ongoing groups that meet at least once per year, comprised of no more than 50 federal, state and local members." [9]

The FBI Laboratory 2005 Report included a section, entitled "Scientific Working Groups", stating:

> *"The FBI Laboratory sponsors scientific working groups (SWGs) to improve forensic science practices and build consensus ... the SWGs create, prepare, and publish standards and guidelines for their constituents in the forensic community. These documents provide crime laboratories a solid basis for operational requirements. Enforcement of the guidelines is left to the appropriate governing agency and each group's internal policies."* [13]

At the time when the report was written (in 2005), 11 SWGs that had been established, as listed on pages 37–38 of The FBI Laboratory 2005 Report, were for: Firearms and Toolmarks; Forensic Document Examination; Materials Analysis; Blood Pattern Analysis; DNA Analysis Methods; Dog and Orthogonal Detection Guidelines; the Forensic Analysis of Chemical Terrorism; the Forensic Analysis of Radiological Materials; Friction Ridge Analysis: Study and Technology; Microbial Genetics and Forensics; and Shoeprint and Tire Tread Evidence [13]. A fuller list was published by the Consortium of Forensic Science Organizations [11].

According to a US National Institute of Standards and Technology (NIST) website [14], the list of TWGs and SWGs, and the years of conversion (from TWGs to SWGs) are shown in **Table 2**.

Organization of Scientific Area Committee (OSAC). The National Technology Transfer and Advancement Act of 1995, signed into law by President Clinton on March 7, 1996, mandates that "all federal agencies use technical standards developed and adopted by voluntary consensus standards bodies, as opposed to using government-unique standards. … establishes the National Institute of Standards and Technology (NIST) as the agency responsible for coordinating conformity assessment activities" [15]. Further guidance was published in 2016 through the Office of Management and Budget (OMB) Circular A-119, directing government strategy for standards development and conformity assessment [16].

As stated by Nakich [17],

> *"The July 2015 issue of Forensic Science Review detailed the origin of the Organization of Scientific Area Committees (OSAC) for forensic science* [18]. *To summarize, in 2013 the US National Institute of Standards and Technology (NIST) and the US Department of Justice (DOJ) signed a memorandum of*

Table 2. TWGs and SWGs — Acronym, full name (URL), and year of creation [14]

Acronym	Full name (URL)	Year TWG	Year SWG
FISWG	Facial Identification Scientific Working Group (http://www.fiswg.org/)	—	2009
SWGFEX	Scientific Working Group for Fire and Explosive Scenes (http://www.twgfex.org/)	1998	1999
SWGGUN	Scientific Working Group for Firearms and Toolmarks (http://www.swggun.org/)	—	1998
SWGANTH	Scientific Working Group for Forensic Anthropology (https://www.nist.gov/topics/forensic-science/anthropology-subcommittee)	—	2008
SWGDOC	Scientific Working Group for Forensic Document Examination (http://www.swgdoc.org/)	1997	1999
SWGGEO	Scientific Working Group for Geological Materials (http://www.swggeo.org/%20)	—	2011
SWGIT	Scientific Working Group for Imaging Technology (http://www.swgit.org/)	1997	1999
SWGTREAD	Scientific Working Group for Shoeprint and Tire Tread Evidence (http://www.swgtread.org/)	—	2004
SWGDRUG	Scientific Working Group for the Analysis of Seized Drugs (http://www.swgdrug.org/)	1997	1999
SWGWILD	Scientific Working Group for Wildlife Forensics (http://www.wildlifeforensicscience.org/certification/swgwild/)	—	2011
SWGSTAIN	Scientific Working Group on Bloodstain Pattern Analysis (http://www.swgstain.org/)	—	2002
SWGDE	Scientific Working Group on Digital Evidence (http://www.swgde.org/)	—	1998
SWGDVI	Scientific Working Group on Disaster Victim Identification (http://www.swgdvi.org/)	—	2010
SWGDAM	Scientific Working Group on DNA Analysis Methods (http://www.swgdam.org/)	1998	1999
SWGDOG	Scientific Working Group on Dogs and Orthogonal Detection Guidelines (http://www.swgdog.org/)	—	2004
SWGTOX	Scientific Working Group on Forensic Toxicology (http://www.swgtox.org/)	—	2009
SWGFAST	Scientific Working Group on Friction Ridge Analysis, Study and Technology (http://www.swgfast.org/)	1995	1998
SWGGSR	Scientific Working Group on Gun Shot Residue (http://www.swggsr.org/)	—	2007
SWGMAT	Scientific Working Group on Materials Analysis (http://www.swgmat.org/)	1992	1996
SWGMDI	Scientific Working Group on Medicolegal Death Investigation (http://www.swgmdi.org/)	—	2011

understanding for a new initiative to strengthen the practice of forensic science. ... The OSAC consists of a Forensic Science Standards Board (FSSB), three resource committees, five scientific area committees, and 24 subcommittees[a] *(**Figure 1**), and has a total of 542 members from various disciplines and organizations including federal, state, and local government, private sector, and academia."* [17]

The OSAC unified and incorporated much of the SWGs' efforts including annodated bibliographies of fundational forensic science research created in 2011 and 2012 by several SWGs [19]. OSAC, administered by NIST, was tasked to:

"*improve forensic practices by facilitating the development and promulgation of technically sound consensus-based documentary standards and guidelines for forensic science; promote standards and guidelines that are fit-for-purpose and based on sound scientific principles; promote the use of the OSACs standards and guidelines by accreditation and certification bodies, and establish and maintain working relationships with other similar organizations.*" [20]

[a]One additional subcommittee (Crime Scene Investigation) was added in 2019 (*https://www.nist.gov/news-events/news/2019/12/osac-adds-25th-standard-registry*).

It should be emphasized that SWGs and OSAC are not regulatory bodies and documents promulgated are left up to individual entities to adopt and implement [4]. An updated structure of OSAC (OSAC 2.0), as shown in **Figure 2** [21], consists of one FSSB, seven SACs, 22 discipline-specific subcommittees (SCs), and FSSB Resource Task Groups [22].

"Changes to OSAC's structure include the addition of a new scientific area committee (SAC) for forensic medicine and the separation of the chemistry SAC into two SACs, each focused on a different aspect of forensic chemistry. Closely related subcommittees have been combined, reducing their number from 25 to 22. The organization also now allows for the formation of interdisciplinary committees to address topics that span multiple traditional forensic disciplines. These changes will improve internal coordination and reduce duplication of effort." [23]

FSSB serves as the governing board of the OSAC structure to facilitate the promulgation of standards that will support the development of quality benchmarks and enhance consistency across the forensic science community [24]. The SACs and SCs are responsible for drafting seed documents for one or more forensic disciplines and

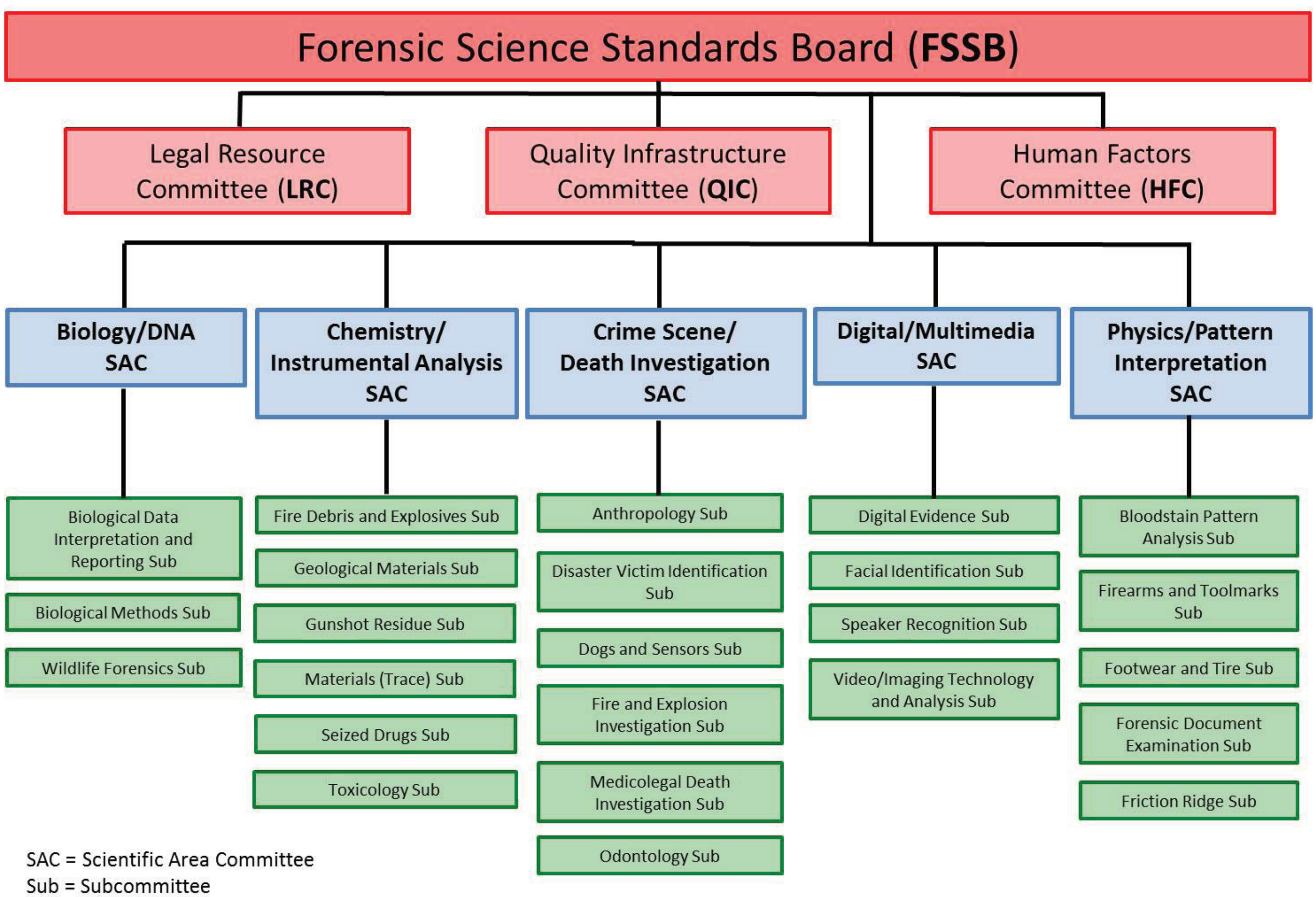

Figure 1. Organization of Scientific Area Committees and Subcommittees (March 17, 2015 version) (*https://www.nist.gov/system/files/documents/forensics/OSAC-Block-Org-Chart-3-17-2015.pdf*).

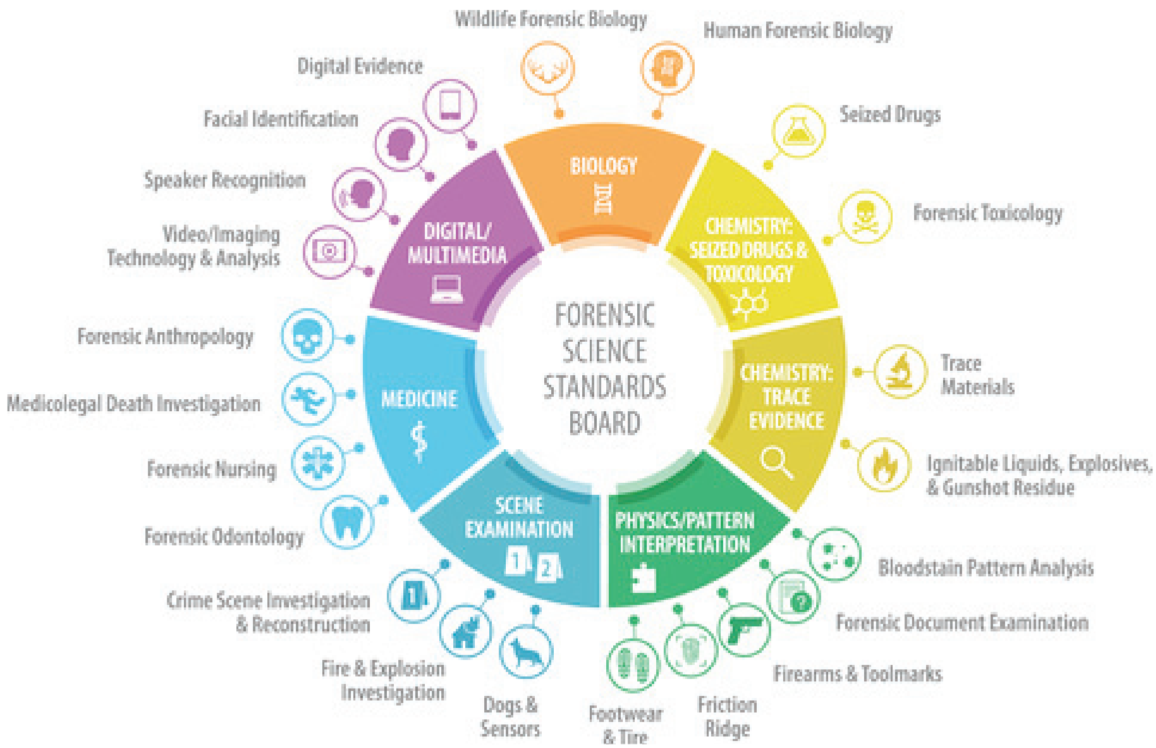

Figure 2. Organization of Scientific Area Committees (OSAC) units [21].

then sending them to Standards Developing Organizations (SDOs) to develop and publish via voluntary consensus standards procedures.

The updated OSAC structure is designed to streamline

> *"the processes to develop draft standards, allow public comment earlier, and have OSAC draft documents available on the OSAC Registry while under development at an SDO. Once the standards are published by an SDO, the FSSB oversees approving the placement of published standards onto the OSAC Registry. The Registry is available on the OSAC website, and of note, ANSI accreditation of a standard is not required by the OSAC Registry"* [4].

At the end of FY 2021, 67 published standards have been approved and posted to the OSAC Registry (**Table 3**) [25].

Forensic Science Standards

A major criticism of forensic science relates to the reliability and validity of scientific principles and analyses. Forensic science standards address this by establishing the application of objective science in a uniform way. By requiring seed documents created by OSAC subcommittees to go through an accredited SDO process, all stakeholders, including the criminal justice and legal communities, academia, and the public at large (as noted above), can advance the foundation of forensic science. Accredited SDOs ensure that the process is open, fair, balanced, equitable, accessible, and responsive to stakeholders' needs (due process) [4]. Consensus reflects substantial agreement has been reached by a simple majority but does not necessarily indicate unanimity. At this time, "[t]here are four SDOs that develop standards for forensic science:

- American Dental Association (ADA), which serves the forensic odontology community;
- ASTM International, which develops standards in several forensic disciplines;
- National Fire Protection Association (NFPA), involved with arson investigations; and
- Academy Standards Board (ASB), which is the only US-accredited[b] SDO dedicated entirely to the creation and maintenance of forensic science standards." [4]

Concluding Remarks

Continuing to strengthen forensic science requires sustained effort on the part of forensic science practitioners. Participating in professional organizations provides opportunities to widely disseminate evolving scientific advancements through peer-reviewed publications, annual meetings (where scientific sessions are held), and virtual training. Such organizations also advocate for the integrity of practitioners and facilitate the development of a vigorous culture in the profession. On-the-job training for forensic scientists shifted to formal education with the recognition

[b]American National Standards Institute (ANSI; *https://www.ansi.org/*) serves as the accreditation body to accredit SDOs for developing American National Standards.

Table 3. Published standards approved and posted to the OSAC Registry [25]

Scientific area	Posted standard (date added)
Anthropology	• ANSI/ASB Best Practice Recommendation 089, Best Practice Recommendation for Facial Approximation in Forensic Anthropology, First Edition, 2020 (added September 7, 2021).
Biology/DNA	• ANSI/ASB Standard 023, Standard for Training in Forensic DNA Isolation and Purification Methods, First Edition, 2020 (added August 3, 2021). • ANSI/ASB Standard 110, Standards for Training in Forensic Serological Methods, First Edition, 2020 (added August 3, 2021). • ANSI/ASB Standard 115, Standard for Training in Forensic Short Tandem Repeat Typing Methods using Amplification, DNA Separation, and Allele Detection, First Edition, 2020 (added August 3, 2021). • ANSI/ASB Standard 116, Standard for Training in Forensic DNA Quantification Methods, First Edition, 2020 (added August 3, 2021). • ANSI/ASB Standard 018, Standard for Validation of Probabilistic Genotyping Systems, First Edition, 2020 (added May 4, 2021). • ANSI/ASB Standard 022, Standard for Forensic DNA Analysis Training Programs, First Edition, 2019 (added September 1, 2020). • ANSI/ASB Standard 020, Standard for Validation Studies of DNA Mixtures, and Development and Verification of a Laboratory's Mixture Interpretation Protocol, First Edition, 2018 (added May 12, 2020). • ANSI/ASB Standard 040, Standard for Forensic DNA Interpretation and Comparison Protocols, First Edition, 2019 (added May 12, 2020).
Bloodstain Pattern Analysis	• ASB Technical Report 033, Terms and Definitions in Bloodstain Pattern Analysis, First Edition, 2017 (added June 3, 2020).
Crime Scene Investigation & Reconstruction	
Digital Evidence	• ASTM E2916-19e1 Standard Terminology for Digital and Multimedia Evidence Examination (added July 7, 2020). • ASTM E3017-19 Standard Practice for Examining Magnetic Card Readers (added July 7, 2020). • ASTM E3150-18 Standard Guide for Forensic Audio Lab Setup and Maintenance (added July 7, 2020).
Dogs & Sensors	• ASB Technical Report 025, Crime Scene/Death Investigation — Dogs and Sensors — Terms and Definitions, First Edition, 2017 (added October 1, 2019).
Facial Identification	• ASTM E2916-19e1 Standard Terminology for Digital and Multimedia Evidence Examination (added July 7, 2020). • ASTM E3115-17 Standard Guide for Capturing Facial Images for Use with Facial Recognition Systems (added October 1, 2019). • ASTM E3148-18 Standard Guide for Postmortem Facial Image Capture (added October 1, 2019). • ASTM E3149-18 Standard Guide for Facial Image Comparison Feature List for Morphological Analysis (added February 14, 2019).
Fire & Explosion Investigation	• NFPA 921:2017 Guide for Fire and Explosion Investigations (added November 1, 2017). • NFPA 1033:2014 Standard for Professional Qualifications for Fire Investigator (added December 22, 2016).
Fire Debris	• ASTM E3245-20e1 Standard Guide for Systematic Approach to the Extraction, Analysis, and Classification of Ignitable Liquids and Ignitable Liquid Residues in Fire Debris Samples (added May 4, 2021). • ASTM E3197-20 Standard Terminology Relating to Examination of Fire Debris (added April 6, 2021). • ASTM E1388-17 Standard Practice for Static Headspace Sampling of Vapors from Fire Debris Samples (added December 1, 2020). • ASTM E1412-19 Standard Practice for Separation of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration with Activated Charcoal (added December 1, 2020). • ASTM E1413-19 Standard Practice for Separation of Ignitable Liquid Residues from Fire Debris Samples by Dynamic Headspace Concentration onto an Adsorbent Tube (added December 1, 2020). • ASTM E3189-19 Standard Practice for Separation of Ignitable Liquid Residues from Fire Debris Samples by Static Headspace Concentration onto an Adsorbent Tube (added December 1, 2020).
Firearms & Toolmarks	• ANSI/ASB Standard 093, Standard Test Method for the Forensic Examination and Testing of Firearms, First Edition, 2020 (added November 2, 2021). • ANSI/ASB Best Practice Recommendation 068, Safe Handling of Firearms and Ammunition, First Edition, 2020 (added April 6, 2021).
Footwear & Tire	• ANSI/ASB Best Practice Recommendation 049, Best Practice Recommendation for Lifting of Footwear and Tire Impressions, First Edition, 2020 (added September 7, 2021). • ANSI/ASB Best Practice Recommendation 021, Best Practices for the Preparation of Test Impressions from Footwear and Tires, First Edition, 2019 (added May 4, 2021).
Gunshot Residue Analysis	• ASTM E1588-20 Standard Practice for Gunshot Residue Analysis by Scanning Electron Microscopy/Energy Dispersive X-Ray Spectrometry (added September 7, 2021).
Medicolegal Death Investigation	• ANSI/ASB Best Practice Recommendation 009, Best Practice Recommendations for the Examination of Human Remains by Forensic Pathologists in the Disaster Victim Identification Context, First Edition, 2019 (added September 7, 2021)

Table 3. (Continued)

Scientific area	Posted standard (date added)
	• ANSI/ASB Best Practice Recommendation 007, Postmortem Impression Submission Strategy for Comprehensive Searches of Essential Automated Fingerprint Identification System Databases, First Edition, 2018 (added September 5, 2019). • ANSI/ASB Best Practice Recommendation 010, Forensic Anthropology in Disaster Victim Identification: Best Practice Recommendations for the Medicolegal Authority, First Edition, 2018 (added September 5, 2019).
Odontology	• ADA 1077-2020 Human Age Assessment by Dental Analysis (added November 2, 2021 and distributed with permission by the ADA). • ADA 1088-2017D Human Identification by Comparative Dental Analysis (added March 7, 2019). • ANSI/ADA 1058-2010D Forensic Dental Data Set (added February 14, 2019).
Seized Drugs	• ASTM E3255-21 Standard Practice for Quality Assurance of Forensic Science Service Providers Performing Forensic Chemical Analysis (added November 2, 2021). • ASTM E1968-19 Standard Practice for Microcrystal Testing in Forensic Analysis of Cocaine (added July 6, 2021). • ASTM E1969-19 Standard Practice for Microcrystal Testing in Forensic Analysis for Methamphetamine and Amphetamine (added July 6, 2021). • ASTM E2125-19 Standard Practice for Microcrystal Testing in Forensic Analysis for Phencyclidine and its Analogues (added July 6, 2021). • ASTM E2882-19 Standard Guide for Analysis of Clandestine Drug Laboratory Evidence (added July 6, 2021). • ASTM E2329-17 Standard Practice for Identification of Seized Drugs (added August 7, 2018). • ASTM E2548-16 Standard Guide for Sampling Seized Drugs for Qualitative and Quantitative Analysis (added June 1, 2021).
Toxicology	• ANSI/ASB Standard 053, Standard for Report Content in Forensic Toxicology, First Edition, 2020 (added March 2, 2021). • ANSI/ASB Standard 036, Standard Practices for Method Validation in Forensic Toxicology, First Edition, 2019 (added July 7, 2020). • ANSI/ASB Best Practice Recommendation 037, Guidelines for Opinions and Testimony in Forensic Toxicology, First Edition, 2019 (added November 5, 2019). • ANSI/ASB Standard 017, Standard Practices for Measurement Traceability in Forensic Toxicology, First Edition, 2018 (added June 18, 2019).
Trace Evidence	• ASTM E3260-21 Standard Guide for Forensic Examination and Comparison of Pressure Sensitive Tapes (added October 5, 2021). • ASTM E3272-21 Standard Guide for Collection of Soils and Other Geological Evidence for Criminal Forensic Applications (added September 7, 2021). • ASTM E3233-20 Standard Practice for Forensic Tape Analysis Training Program (added November 3, 2020). • ASTM E3234-20 Standard Practice for Forensic Paint Analysis Training Program (added November 3, 2020). • ASTM E1967-19 Standard Test Method for the Automated Determination of Refractive Index of Glass Samples Using the Oil Immersion Method and a Phase Contrast Microscope (added July 7, 2020). • ASTM E2330-19 Standard Test Method for Determination of Concentrations of Elements in Glass Samples Using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) for Forensic Comparisons (added July 7, 2020). • ASTM E3085-17 Standard Guide for Fourier Transform Infrared Spectroscopy in Forensic Tape Examinations (added September 11, 2018). • ASTM E1610-18 Standard Guide for Forensic Paint Analysis and Comparison (added June 26, 2018). • ASTM E2937-18 Standard Guide for Using Infrared Spectroscopy in Forensic Paint Examinations (added June 26, 2018). • ASTM E2927-16e1 Standard Test Method for Determination of Trace Elements in Soda-Lime Glass Samples Using Laser Ablation Inductively Coupled Plasma Mass Spectrometry for Forensic Comparisons (added June 5, 2018). • ASTM E2926-17 Standard Test Method for Forensic Comparison of Glass Using Micro X-ray Fluorescence (μ-XRF) Spectrometry (added July 31, 2017).
Video/Imaging Technology & Analysis	• ASTM E2916-19e1 Standard Terminology for Digital and Multimedia Evidence Examination (added July 7, 2020).
Wildlife Forensics	• ANSI/ASB Standard 019, Wildlife Forensics General Standards, First Edition, 2019 (added March 2, 2021). • ANSI/ASB Standard 029, Report Writing in Wildlife Forensics: Morphology and Genetics, First Edition, 2019 (added March 2, 2021). • ANSI/ASB Standard 028, Wildlife Forensics Morphology Standards, First Edition, 2019 (added June 3, 2020). • ANSI/ASB Standard 047, Wildlife Forensics Validation Standard—Validating New Primers for Sequencing, First Edition, 2019 (added June 3, 2020).
Interdisciplinary	• ANSI/NIST ITL-1: 2011 (Update 2015) Data Format for the Interchange of Fingerprint, Facial & Other Biometric Information (added November 3, 2020). • ISO 21043-2 Forensic Sciences — Part 2: Recognition, recording, collecting transport and storage of items (added December 3, 2019). • ASTM E2917-19a Standard Practice for Forensic Science Practitioner Training, Continuing Education, and Professional Development Programs (added November 5, 2019). • ISO/IEC 17025:2017 General Requirements for the Competence of Testing and Calibration Laboratories (added June 18, 2019). • ISO/IEC 17020:2012 Conformity Assessment — Requirements for the Operation of Various Types of Bodies Performing Inspection (added April 18, 2017).

of accredited forensic science programs. FEPAC accreditation distinguishes high-quality forensic science university programs, ensuring a comprehensive science education designed to prepare students for a career in criminalistics and forensic science. As stated by Howe et al. [4], "[t]he TWGs and SWGs were a strong start for improving quality within forensic disciplines. From a historical lens, we can see how they prepared the forensic and legal communities to voluntarily adopt and implement consensus-based documents." With significantly enlarged resources, OSAC has been able to move the expanded scope of the mandate in a much faster pace by creating draft documents to go through an accredited SDO process. What remains to be seen is how quickly the nation's laboratories, especially those with very limited resources, would be able to fully adopt these standards into their daily practices.

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NEW BOOKS AND BOOK REVIEWS

New Forensic Science Books

The Art and Science of Expert Witness Testimony: A Multidisciplinary Guide for Professionals
K. Postal
Routledge/CRC Press: Boca Raton, FL, US; 2021

The Basics of Investigating Forensic Science, A Laboratory Manual, 2nd ed
K. Mirakovits, G. Londino-Smolar
CRC Press: Boca Raton, FL, US; 2021

Blood Traces: Interpretation of Deposition and Distribution
P. R. De Forest, P. A. Pizzola, B. W. Kammrath
Wiley-Blackwell: Somerset, NJ, US; 2021

Bloodstain Pattern Analysis with an Introduction to Crime Scene Reconstruction, 3rd ed
T. Bevel, R. M. Gardner
CRC Press: Boca Raton, FL, US; 2021

Comparative Bone Identification: Human Subadult and Nonhuman — A Field Guide
D. L. France
CRC Press: Boca Raton, FL, US; 2021

Courtroom Testimony for Fingerprint Examiners
H. M. Daluz
CRC Press: Boca Raton, FL, US; 2021

Crime Science and Digital Forensics: A Holistic View
A C. Ijeh, K. Curran, Eds
CRC Press: Boca Raton, FL, US; 2021

Cyber Forensics: Examining Emerging and Hybrid Technologies
A. J. Marcella, Ed
CRC Press: Boca Raton, FL, US; 2021

DiMaio's Forensic Pathology, 3rd ed
V. J. M. DiMaio, D. K. Molina
CRC Press: Boca Raton, FL, US; 2021

Forensic Anthropology Teams in Latin America
S. Dutrénit-Bielous, Ed
Routledge/CRC Press: Boca Raton, FL, US; 2020

Forensic Biology, 2nd ed
R. Li
CRC Press: Boca Raton, FL, US; 2021

Forensic DNA Profiling: A Practical Guide to Assigning Likelihood Ratios
J-A. Bright, M. Coble
CRC Press: Boca Raton, FL, US; 2021

Forensic Forestry: A Guidebook for Foresters on the Witness Stand
R. P. Latham
CRC Press: Boca Raton, FL, US; 2021

Forensic Psychology and Neuropsychology for Criminal and Civil Cases, 2nd ed
H. V. Hall, J. Poirier, Eds
CRC Press: Boca Raton, FL, US; 2021

Forensic Science: The Basics, 4th ed
K. Mirakovits, J. A Siegel
CRC Press: Boca Raton, FL, US; 2021

Forensic Toxicology: Principles and Concepts, 2nd ed
N. Lappas, C. Lappas
Academic Press/Elsevier: Waltham, MA, US; 2021

Handbook of Venoms and Toxins of Reptiles, 2nd ed
S. P. Mackessy, Ed
CRC Press: Boca Raton, FL, US; 2021

An In-Depth Guide to Mobile Device Forensics
C. Easttom
CRC Press: Boca Raton, FL; US

Interpreting Complex Forensic DNA Evidence
J. M. Taupin
CRC Press: Boca Raton, FL, US; 2021

Investigative Interviewing: Adopting a Forensic Mindset
J. E. Grimes, III
CRC Press: Boca Raton, FL, US; 2021

Next Generation Sequencing in Forensic Science: A Primer
K. M. Elkins, C. B. Zeller
CRC Press: Boca Raton, FL, US; 2021

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Book Review

Crime Scene Documentation — Preserving the Evidence and the Growing Role of 3D Laser Scanning

Robert S. Galvin

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Reviewed by

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Robert Galvin is the author of the book entitled *Crime Scene Documentation — Preserving the Evidence and the Growing Role of 3D Laser Scanning*. Mr. Galvin "has 43 years of experience in public relations, newspaper reporting and writing, and trade press writing. During the last 15 years, he has concentrated on the law enforcement, public safety, and forensic science sectors to write and publish trade press articles tied to crime scene investigations and scene documentation."[a] Related to the preparation of this book, Mr. Galvin "has worked with vendors offering software and technology products that enable law enforcement agencies and crash/crime scene reconstructionists to record evidence, data, and contents at vehicle crash scenes and crime scenes. … Mr. Galvin interviewed a multitude of law enforcement, public safety, forensic, and crime investigation professionals, including crime scene investigators (CSIs), crime detectives, snipers, S.W.A.T. operators, criminalists, arson investigators, police chiefs, sheriff's deputies who investigate crime scenes, vehicle crash and crime scene reconstructionists, and forensic experts."[a]

Part I (introduction) of this book includes five chapters, providing (a) a brief history of forensic science (Chapter 1); (b) challenges of crime scene documentation (Chapter 2); and (c) an overview of methodologies, including the preparation (Chapter 3), current approach (Chapter 4), and photogrammetry as a tool for crime scene documentation (Chapter 5), including some technical details of photogammetry and 3D laser technologies.

Part II (Chapters 6–19) covers various aspects related to the use of 3D laser scanning technology in crime scene investigation. The author emphasizes the importance of professional training on laser scanner for CSIs in Chapter 8 and the requirement to create a 3D scanned scene product that can be delivered in court in Chapter 9.

Other new technologies related to scene documentation are also covered. For example, in Chapter 11, a new add-on, dynamic scanning using a tablet, is introduced to 3D laser scanning technology. Its unique application to the existing 3D laser scanning is further explained. The use of tablet scanning can reduce the number of people who must enter the scene. The tablet can be used alone and can be integrated into other mapping technology. In Chapter 12, the application of unmanned aerial vehicles (UAVs) or drones for crime scene documentation is introduced. This type of scene documentation technique can assist in lengthy, hard-to-record crash scenes. The scene data can now be recorded from the sky for murder scenes that span several blocks. In addition to passive crime scene documentation using 3D laser scanning technology, Part II covers other unique applications, such as risk assessment and security planning (Chapter 13).

Specific applications of 3D laser scanning technology in crime scene reconstruction are discussed in detail: shooting scene reconstruction (Chapter 15), bloodstain pattern analysis (Chapter 16), and crash vehicle damage analysis (Chapter 17). Combining other technologies — such as photogrammetry, drone, dynamic (tablet) 3D scanning — into the 3D laser scanning workflow is also discussed in these case examples.

Furthermore, more accurate measurement using a 3D point cloud is explained in Chapter 18. Laser-based photogrammetry can override challenges related to other camera or video recording systems. All in all, 3D laser scanning technology is viewed as the most powerful and comprehensive for crime scene reconstruction. However, the author notes that the 3D laser scanning technology should never be viewed as the only way to document crime scenes and mapping evidence. The practitioners prefer integrating one or more mapping technologies with 3D laser scanning to ensure thorough documentation with multiple scene perspectives (Chapter 19).

Overall, this book explains the emerging technology of 3D laser scanning as a critical tool for scene documentation. The unique crime scene data provided by 3D laser scanning technology can assist the jury in experiencing multiple scene perspectives, positions, and locations of people when the practitioners apply 3D laser scanning to create animations for crime scene reconstruction. The ultimate experience offered by the technology enables the jury to see various pieces of evidence that may be critical to a case.

In conclusion, the author reviews the background of crime scene documentation and demonstrated the importance of 3D laser scanning as an essential tool for crime scene documentation. The benefits of 3D laser scanning technology relative to its reliability and accuracy are detailed, along with the illustration of its applications in multiple case scenarios. This book serves as an invaluable resource for CSIs interested in new technologies to document a scene, to map evidence, and to reconstruct scenes.

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[a]Information taken from the publisher's website on this book: *https://www.routledge.com/Crime-Scene-Documentation-Preserving-the-Evidence-and-the-Growing-Role/Galvin/p/book/9780367652302*.

COMMENTARY

Investigative Genetic Genealogy: An Ethical and Privacy Assessment Framework Tool Is Needed

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Investigative genetic genealogy (IGG) is a technique for identifying criminal suspects that involves uploading a crime scene DNA profile to one or more genetic genealogy databases to identify a criminal offender's genetic relatives and, eventually, locating the offender within the family tree in both cold and active law enforcement cases. Law enforcement agencies typically employ the services of a genetic genealogist who will work with any DNA matches retrieved following the upload of DNA profiles, in an attempt to identify the victim or suspect of interest through networks of cousin matches. In recent criminal cases, IGG was used on free online genetic databases, sparking high controversy in the public domain [1–4]. In this commentary, we argue for the urgent need for an ethical and privacy assessment framework that helps to balance the risks and benefits of IGG to society.

The Golden State Killer case in 2018 is the most well-known case for which IGG was used [3,5]. During this case, a free online genetic database populated by individuals researching their family trees — *GEDmatch*[a] — was used to identify Joseph DeAngelo, a former police officer, as the suspect on 12 unsolved murders and at least 45 rapes committed throughout California from 1976 to 1986. Using the *GEDmatch* genetic genealogy database, the police identified DeAngelo by first identifying his relatives through matches with a network of genetic cousins and extensive family-tree-building. The website's algorithm generated a partial match that allowed investigators to construct family trees and scour them for potential suspects. However, this "fishing" for potential suspects was only successful after investigators matched DeAngelo's genetic data, which was collected from an object that he discarded while under surveillance, to a crime scene DNA profile. This entire process was long and complex, which is quite far from the direct and quick procedure that the media tried to convey to the general public [6].

__Helena Machado (left)__ is a professor of sociology and dean of the Institute for Social Sciences at the University of Minho (Braga, Portugal). During her career Dr. Machado has been developing collaborative research with forensic geneticists, with a focus on social, political, and ethical implications on uses of DNA technologies in the criminal justice system. In recent years, Dr. Machado coordinated a long-term study on DNA-data sharing for combating crime and terrorism among police forces in the European Union (2015–2021, funded by the prestigious Consolidator Grant of the European Research Council). She has authored more than 200 academic publications; recent works include the book Forensic Genetics in the Governance of Crime *(Palgrave: London, UK; 2020) translated to Portuguese-Brazilian, and simplified Chinese, and* Genetic Surveillance and Crime Control: Social, Cultural and Political Perspectives *(Routledge: Milton Park, UK; 2021) (both books co-authored with Rafaela Granja).*

__Susana Silva (right)__, Ph.D. in sociology, is senior researcher, chair of the Department of Health and Society, and member of the Board of Directors at the Institute of Public Health of the University of Porto. Dr. Silva has published widely on the societal and ethical challenges emerging from the uses of reproductive and genetic technologies in biomedicine and in forensics. Her research interests include people-centered and integrated care, and contemporary modes of governance of research, health regulation, and clinical practices. Her current multi- and mixed-methods research engages sociological and ethical perspectives to foster safe and innovative health technologies and to reduce social and health inequalities.

Being currently used in connection with hundreds of cases in the US, IGG raises questions about privacy for genetic genealogy database users and their own biological relatives. It should also be noted that long-range familial searches can provide information on millions of individuals, presumably even for those who have not undergone genetic testing, since they might result in a third cousin or closer relative [7–9]. In this ambiguous and complex scenario, it is urgent to debate whether to place limits on police access to genetic genealogy databases [3]. Additional ethical and privacy requirements should be addressed, with robust input from the public [2–4,10,11].

Genetic genealogy has been used for years by people filling out their family trees in direct-to-consumer (DTC) databases or/and in online genealogy databases, but it is a new tool in criminal investigations. It is necessary to fully consider the ethics of this widely unregulated technique as it promises to spread rapidly across the US and enter into police routine [12]. There is also some evidence of IGG potentially being used in other jurisdictions, such as Sweden and the UK [10,13].

Autosomal Short Tandem Repeats vs. Single-Nucleotide Polymorphisms

Unlike traditional forensic DNA analysis used by police forces in criminal identification, which uses autosomal short tandem repeats (STRs) to generate an identity profile from ~20 loci, IGG applied to DTC genetic testing companies, such as *23andMe* or *AncestryDNA*, use microarrays to genotype up to ~1 million single-nucleotide polymorphisms (SNPs). The STRs used in traditional forensic DNA analysis are generated by accredited forensic laboratories that must comply with a host of quality assurance standards and requirements. In addition, the DNA profiles are usually from people who have already been involved in the criminal justice system — persons who have been convicted of, and in some cases arrested for, crimes. By contrast, genetic genealogy databases use SNPs generated by commercial test providers. SNPs are more evenly (and densely) distributed throughout a person's genome than STRs and hence can carry information about a person's medical history and appearance. If analyzed with regard to patterns of linked variation along sections of chromosomes, SNPs can also be used to identify more distant genetic relatives than STRs.

For these reasons, in terms of potentially sensitive information gathered from genetic analysis IGG represents an expansion over standard forensic DNA analysis used in criminal investigation. IGG also represents an expansion in terms of the population of individuals whose genetic information might be searched in a crime investigation: not only genetic genealogy database participants but also all their nonparticipant relatives whose names might become part of an investigation by virtue of the fact that they are members of a suspect's family tree.

Informed Consent and Human Rights

Integration of informed consent is now being adopted in some genealogy databases and by a few companies providing DTC genetic testing. While consumers may consent to uploading their genetic profiles to sites like *GEDmatch*, which now require consumers to opt-in for law enforcement access to their respective data, their biological relatives have not consented to their now indirect inclusion in these databases. Individuals who are unaware that they could be matched, based on a relative's familial DNA profile in a database, lack the right to expunge their own or their family member's genetic record from a commercial or publicly available database [14].

As noted by Samuel and Kennett [4], using "informed consent" as a kind of "ethics panacea" engenders the risk of placing ethics responsibility onto the database user. The focus on individual-based consent also narrows ethical discussion by shielding other substantive political and societal issues from critical scrutiny, such as public interest issues, societal good, state power, and oversight mechanisms [4,15]. This diminished vision of ethics (and/or of meaningful consent) limits a more shared understanding of responsibility among individuals, institutions, and society [16], ignoring other ethical consequences of IGG — that a range of human rights issues existed when considering IGG at an international level; and that IGG led to a repurposing of the intentions of genetic genealogy databases [4].

Some commentators claim that expanding law enforcement investigations to encompass genealogical databases may help to remedy the racial and ethnic disparities that plague traditional forensic searches typically limited to individuals arrested or convicted of certain crimes [3,17]. Racial and ethnic disparities throughout the criminal justice system are reproduced in the racial and ethnic makeup of traditional police DNA databases in the United States, particularly Black Americans and Latinos [18]. DTC databases and online publicly available genealogy databases consist disproportionately of individuals of European descent [8]. However, it is a fallacious argument that increasing the number of white populations available for law enforcement searches is potentially a positive method to counter the skewed representation of racial minorities in police DNA databases. Although increasing the available data set for potential suspects may lead to more arrests of European-descended suspects, racial minorities will not necessarily be arrested with any less frequency. Conversely, the use of DTC and publicly available genealogy data sets does not necessarily solve racial disparities and existing bias and prejudice on the criminal justice system.

Ethical and Privacy Concerns

A privacy tool that could be used by all stakeholders directly involved in IGG should cover the following items:

- **Transparency.** Are ancestry and genealogical websites, as well as personal genetic providers, transparent about their granting or denial of law enforcement access? It must be emphasized that the services should issue annual transparency reports regarding law enforcement access [2].
- **Access Criteria.** Do genetic genealogy services and DTC databases require warrants for the police to access genetic data? More clear and restrictive regulation on access criteria is needed as law enforcement begins to consider the potential investigatory power of utilizing consumer datasets.
- **Quality Assurance.** Do publicly available genealogy databases, as well as DTC databases, follow internationally recognized quality assurance for DNA analysis and standards of sharing genetic data? Companies that provide genetic services remain largely unregulated, particularly regarding quality assurance and standards of sharing personally identifiable information with third parties [7].
- **Proportionality.** How can a balance between individual and public rights — a balance between the use of genetic information to provide investigative leads in pursuit of public safety while limiting the threat to personal privacy — be achieved in IGG? Proportionality is context dependent, requiring careful assessment of competing interests and balance of positive versus negative effects to achieve an optimal outcome and the most favorable option [19].

All of the above concerns require us to consider the adoption of a broader ethical and privacy assessment approach to IGG, such that the process is developed in partnership with all relevant professionals and stakeholders. Database users and the wider public should become assured that they have been engaged and listened to. Finally, guidance to limit activity in investigating potential distant relatives would be needed, as well as clear indications related to the kind of genetic information that would be revealed in the analysis in addition to genealogical information, including sensitive medical and personal data.

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