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Professional Review and Commentary[a]

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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.

Canada Legalizes Recreational Cannabis

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On October 17, 2018, Canada became the first G7 country to legalize recreational cannabis; medical cannabis has been legal in Canada on a very restricted basis since 2000, when higher courts ruled that Canadians have a constitutional right of access to medical marijuana [1].

The recently passed Cannabis Act (Bill C-45) [2] created a strict legal framework to control the production, distribution, sale, and possession of recreational cannabis across Canada in order to:

- Keep cannabis out of the hands of minors;
- Keep profits out of the hands of criminals; and
- Protect public health and safety by allowing adults access to safe, legal cannabis [3].

What Is Legal in Canada

Adults who are 18 years of age or older are legally able to:

- Possess up to 30 g of legal cannabis dried or equivalent;
- share up to 30 g of legal cannabis with other adults;
- Buy fresh or dried cannabis from a provincially licensed retailer;
- Grow from licensed seed or seedlings up to four cannabis plants per residence for personal use; and
- Make cannabis products such as food and drinks at home, so long as organic solvents are not used to create these products.

The two main approaches of cannabis legalization appear to be to have restrictions on the marketing/advertising of this drug similar to those on tobacco products, and to regulate cannabis-impaired driving similar to alcohol-impaired driving (Bill C-46) [4].

Marketing/Advertising of Cannabis

The Cannabis Act (Bill C-45) allows only factual, accurate information about the cannabis products (e.g., tetrahydrocannabinol, THC, and cannabidiol, CBD, levels) and does not allow the price to be advertised [2]. Cannabis can also only be advertised in media where it will not be seen by youth. Under Bill C-45, the cannabis industry would not be allowed to conduct:

- Promotion considered appealing to youth;
- Promotion that includes false, misleading, or deceptive information;
- Promotion through sponsorship, testimonials, or endorsements; and
- Promotion using depictions of person, celebrities, characters, or animals [2].

The legal cannabis product must be sold in uniform, plain packaging with prominent rotating health warnings (similar to cigarettes) such as:

> **WARNING: Do not drive or operate machinery after using cannabis.** After cannabis use, coordination, reaction time and ability to judge distances are impaired.
>
> **WARNING: Cannabis can be addictive.** Up to 1 in 2 people who use cannabis daily will become addicted.
>
> **WARNING: Regular use of cannabis can increase the risk of psychosis and schizophrenia.** Higher THC content can increase the risk of psychosis and schizophrenia.
>
> **WARNING: Cannabis smoke is harmful.** Harmful chemicals found in tobacco smoke are also found in cannabis smoke.
>
> **WARNING: Adolescents are at greater risk of harm from cannabis.** Using cannabis as a teenager can increase your risk of becoming addicted.

These health warnings on all legally sold cannabis products should assist in informing and educating the public about the risks of cannabis use, and could counteract the widespread public misconception that cannabis is a harmless drug.

Cannabis-Impaired Driving

Another Cannabis Act (Bill C-46) now allows for police in Canada to conduct several tests at the roadside to determine cannabis impairment, such as an initial breath alcohol screening test (to eliminate the possibility that the impaired driving was due to alcohol, the most common drug); Standardized Field Sobriety Tests (SFSTs); Drug Recognition and Evaluation (DRE); and oral fluid (OF) screening tests [4]. Refusal by the driver to submit to these tests when requested by the police is a Criminal Code offense.

If the driver fails the screening tests and cannabis use is suspected, then a blood sample can be demanded by the police. The result of the blood sample as to THC concentration will determine whether a charge of driving over the THC limit is laid or not.

The per se driving limits for THC in the blood are 2–5 ng/mL for a lesser criminal code offense and >5 ng/mL for a greater offense. Since the combination of alcohol

and THC is known to cause greater impairment of driving ability [5,6] the current BAC limit of 80 mg/100 mL is reduced to 50 mg/100 mL if more than 2.5 ng/mL of THC is detected concurrently.

There are also zero-tolerance laws in most of the provinces of Canada, typically for novice or young drivers and commercial vehicle operators; such laws mainly involve fines and impoundment of motor vehicles, but not criminal code convictions or imprisonment.

Effects of Legalization

There are numerous other laws that also control the use of cannabis, such as no amount of cannabis can be transported across Canada's international borders, it is illegal to sell or give cannabis to anyone under the age of 18 years, and open cannabis is not allowed in motor vehicles. Legal cannabis growers also operate under numerous restrictive laws, to ensure cannabis is not diverted to the black market.

In fact, there are so many laws that in my opinion, it is more likely someone could be charged with a cannabis-related offense now, after legalization, than before.

The launch of the legal selling of cannabis has been uneven across the provinces. Most provinces still only have a few (if any) brick-and-mortar cannabis stores, but online shopping and home delivery is widespread. There have been complaints about the lack of cannabis product, which is to be expected with any initial start-up period of legalization as consumer preference to the different types of cannabis were unknown due to the black market that existed previously.

Decriminalization?

One approach many jurisdictions are considering is the decriminalization of the personal possession and use of cannabis, but all other aspects of such as the cultivating and selling of it would still be illegal. This is like the Dutch approach of "coffee shops", in which people can legally use and buy cannabis there, but it is still illegal for the owners of the shops to grow or purchase cannabis. It is known as "front door, legal; back door illegal" or "gedogen" [7].

Although decriminalization is thought to have the advantage of perhaps not normalizing the drug, it has many problems and is a poor intermediate step to the proper control and regulation of cannabis. For example, the legal growers and cannabis store owners, in Canada, who must pay high regulatory costs, are probably among the first to tip off the police to an illegal grower or competitor who have an unfair advantage in not having to pay such expenses. Whereas if there was just decriminalization, all would be united against the police and regulatory agencies in the illegal trade of cannabis.

Start Low, Go Slow

So far, the legalization of recreational cannabis in Canada has proceeded relatively smoothly. There has been no large increase in cannabis-related motor vehicle collisions or public intoxication or use [8]. However, some of the adverse effect of cannabis take about 3–5 years or more to become apparent, and so it is too soon to assess the ultimate success of legalization [9].

My concerns involve the increasing pressure of "Big Cannabiz" to circumvent restrictions to advertising and promotion; the low federal legal age of 18 years, rather than 21 or 25 years of age as recommended by the Canadian medical community [10]; the legalization of the more problematic cannabis-infused edibles in October 2019 [11]; and no restrictions as to the concentration of THC in cannabis (up to 30% or more) that is sold legally [12]. Legalization should, however, be considered as an ongoing process and the laws should be adapted to changing conditions and evolving cannabis-related problems.

I would suggest that the extensive laws and regulations regarding cannabis legalization in Canada can provide a template for other countries to follow. As with new cannabis users, countries newly legalizing recreational cannabis should "start low and go slow".

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Upcoming Events

2nd World Conference on Analytical & Bioanalytical Chemistry
July 12–13, 2019; Tropicana Las Vegas
Las Vegas, NV, US

International Association of Chiefs of Police Annual Training Conference on Drugs, Alcohol, and Impaired Driving
Aug. 10–12, 2019; Anaheim Marriott
Anaheim, CA, US

International Association for Identification — 2019 International Educational Conference
Aug. 11–17, 2019; Peppermill Resort
Reno, NV, US

T2019: 22nd International Council on Alcohol, Drugs and Traffic Safety Conference
Aug. 18–21, 2019; Shaw Conference Centre
Edmonton, Canada

8th European Meeting on Forensic Archaeology
Aug. 22–23, 2019; Moesgaard Museum
Højbjerg, Denmark

Northwest Association of Forensic Scientists — Annual Conference
Aug. 26–30, 2019; Red Lion Hotel on the River
Portland, OR, US

Outlook Conferences — International Toxicology Conference
Aug. 29–30, 2019; Sercotel Hotel Sorolla Palace
Valencia, Spain

TIAFT 2019: 57th Annual Meeting of the International Association of Forensic Toxicologists
Sept. 2–6, 2019; The International Convention Center
Birmingham, UK

2019 Cannabis Science Conference West
Sept. 4–6, 2019; Oregon Convention Center
Portland, OR, US

28th Congress of the International Society for Forensic Genetics
Sept. 9–14, 2019; Prague Congress Centre
Prague, Czech Republic

2019 International Conference on Forensic Nursing Science and Practice
Sept. 11–14, 2019; New Orleans Marriott
New Orleans, LA, US

2nd International Conference on Forensic Research & Technology
Sept. 18–19, 2019; Holiday Inn Singapore Atrium
Singapore City, Singapore

ISHI 2019: 30th International Symposium on Human Identification
Sept. 23–26, 2019; Palm Springs Convention Center
Palm Springs, CA, US

Society of Forensic Toxicologists — Annual Meeting
Oct. 13–18, 2019; Hyatt Regency
San Antonio, TX, US

SCIX2019 — Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies
Oct. 13–18, 2019; Palm Springs Convention Center
Palm Springs, CA, US

Midwestern Association of Forensic Scientists — 48th Annual Fall Meeting
Oct. 14–18, 2019; Galt House Hotel
Louisville, KY, US

International Forum for Drug & Alcohol Testing — 2019 Conference
Oct. 16–17, 2019; Ottawa Art Gallery
Ottawa, Canada

California Association of Criminalists Seminar — Fall 2019
Oct. 20–26, 2019; DoubleTree Ontario Airport Hotel
Ontario, CA, US

Southwestern Association of Forensic Scientists — 41st Annual Conference
Oct. 27–31, 2019; Renaissance Austin Hotel
Austin, TX, US

The Gulf Cooperation Council's Forensic Conference
Nov. 13–14, 2019; The Gulf Hotel Bahrain
Manama, Bahrain

Northeastern Association of Forensic Scientists — 45th Annual Meeting
Nov. 13–16, 2019; Marriott Lancaster at Penn Square
Lancaster, PA, US

2nd International Caparica Conference in Translational Forensics 2019
Nov. 18–21, 2019; Hotel Aldeia dos Capuchos Golf & SPA
Caparica, Portugal

American Academy of Forensic Sciences — 72nd Annual Meeting
Feb. 17–22, 2020; Anaheim Convention Center
Anaheim, CA, US

PITTCON Conference and Expo
March 1–5, 2020; Convention Center
Chicago, IL, US

Techno Security & Digital Forensic Conference
March 9–11, 2020; Hilton La Jolla Torrey Pines
San Diego, CA, US

ADVANCING THE PRACTICE OF FORENSIC SCIENCE IN THE US — UPDATE

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

NIST conducts research to advance the forensic sciences, supplies forensic laboratories with physical reference standards and data to help ensure accurate test results, and administers the Organization of Scientific Area Committees for Forensic Science (OSAC), which facilitates the development of science-based standards for forensic practice.

In partnership with NIST, the Center for Statistics and Applications in Forensic Evidence (CSAFE) conducts research to develop statistical methods to accurately analyze and interpret pattern and digital evidence. The CSAFE team provides education and training in these new methods to forensic practitioners, members of the judicial community, and other stakeholders nationwide.

The National Institute of Justice (NIJ) within the DOJ is the lead agency for forensic science research and development as well as for the administration of programs that facilitate training, improve laboratory efficiency, and reduce backlogs. The Forensic Technology Center of Excellence (FTCoE), a program of the NIJ, serves as a resource for both practitioners and developers. It assists in the transition of forensic technology from applied research into practice; and in conducting knowledge transfer and outreach.

The National Forensic Laboratory Information System (NFLIS) is a Drug Enforcement Administration (DEA) program within the DOJ that systematically collects results of forensic analyses and other related information from local, regional, and national entities.

The "Professional Review and Commentary" section of FSR has published previous "Updates" for both NIST (since January 2014) and for NIJ's FTCoE (since July 2014). The current semiannual "updates" from these agencies and DEA's NFLIS are included in this issue.

National Institute of Standards and Technology (NIST) and NIST-Sponsored Programs

National Institute of Standards and Technology Forensic Science Update

DNA Mixtures: A Forensic Science Primer*
— What are DNA Mixtures? And Why Can They Sometimes Be So Difficult to Interpret?

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Everyone's DNA is slightly different. Thirty-five years ago, when scientists invented a way to distill those differences into a DNA profile, they revolutionized forensic science. That profile — a sort of genetic fingerprint — gave investigators a new and extremely reliable tool for solving crimes.

DNA profiling can be so powerful and has been used successfully in so many cases that some people think it is nearly infallible. But the reliability of DNA profiling varies, and other things being equal, it is most reliable when the evidence contains plenty of DNA from just one or two people. That's why homicides and sexual assaults — crimes that tend to produce a lot of this type of DNA evidence — made up the bulk of DNA casework for many years.

But in the last decade or so, forensic experts have been analyzing DNA mixtures, which occur when the evidence contains a mixture of DNA from several people. They are also analyzing trace amounts of DNA, including the "touch DNA" left behind when someone touches an object. These types of evidence can be far more difficult to interpret reliably than the DNA evidence typical of earlier decades. With old-school DNA, the results tend to be clear-cut: either a suspect's DNA profile is found in the evidence or it isn't, and non-experts can readily understand what that means. With DNA mixtures and trace DNA, the results can be ambiguous and difficult to understand, sometimes even for the experts.

These more complex types of evidence make up an increasing share of the DNA casework in the US, and labs are rapidly adopting new methods and tools to deal with them. More than just an upgrade to the existing tool set, these changes represent a fundamentally new approach

*Also available in *https://www.nist.gov/featured-stories/dna-mixture-forensic-science-explainer*.

to DNA evidence and mark a profound shift in the field. Given the great weight that DNA evidence carries in the courtroom, it is important that lab analysts, criminal investigators, judges, attorneys — and anyone who might sit on a jury someday — understand these changes. So here's a quick primer on DNA mixtures and trace DNA, what makes them difficult to interpret, and what these changes mean for the future of the field.

Why Have DNA Mixtures and Trace DNA Become So Prevalent?

DNA methods have become extremely sensitive. Forensic scientists once needed a relatively large amount of material, such as a visible blood or semen stain, to produce a DNA profile. Today, they can generate a profile from just a few skin cells that someone left behind when touching an object or surface.

This capability is a significant technological achievement. It also has the potential to allow forensic science to help solve a greater variety of crimes. Investigators might be able to solve a sexual assault, for example, even when very little DNA is recovered. They might investigate a break-in by swabbing the pry bar that was used to force a door, or they might swab a firearm that was used to commit a crime.

But such high sensitivity is a double-edged sword. We often shed small amounts of DNA when we talk, sneeze, and touch things. As a result, many surfaces are likely to contain mixtures of minute amounts of DNA from several people. These mixtures have always been present at crime scenes (**Figure 1**), but when sensitivity was lower, they wouldn't have been detected or, if they were, labs would not have attempted to interpret them. That is no longer the case.

Are All DNA Mixtures Difficult to Interpret?

Some mixtures are relatively easy to interpret. Others are more complex and require greater care. Still others may be too complex to reliably interpret at all. It depends on the specifics of the case.

Three main factors determine the complexity of a mixture[a]:

- How many people contributed DNA to the mixture? More contributors make a mixture more complex, and therefore, more difficult to interpret.
- How much DNA did each person contribute? Even if a mixture contains a significant amount of DNA overall, one or several people might have contributed only a tiny amount. The lower those amounts, the more complex the mixture.
- How degraded is the DNA? DNA degrades over time and with exposure to the elements. This can also increase complexity.

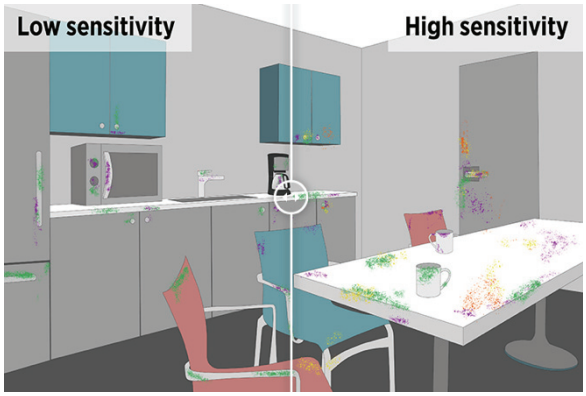

Figure 1. Forensic scientists are likely to detect more DNA mixtures when using high-sensitivity DNA methods than when using low-sensitivity methods. In this imagined crime scene, different colors represent DNA from different individuals. Illustration by K. Irvine/NIST based on a concept illustrated in *Making Sense of Forensic Genetics* (*https://senseaboutscience*).

When does a DNA mixture become too complex to reliably interpret at all? Currently, there are no established standards for deciding this. Different labs have different protocols. When confronted with a particularly complex DNA mixture, some labs will try to interpret it and others won't.

Why Are Complex DNA Mixtures Difficult to Interpret?

To answer this question, it helps to know a bit about DNA profiles. When generating a DNA profile, forensic scientists don't analyze the entire genetic sequence. Instead, they look at roughly 40 short segments of DNA that vary from person to person. Those different variations are called alleles, and the key to knowing a person's DNA profile is knowing which alleles they have.

To find out, forensic scientists need enough genetic material to analyze, so they make millions of copies of the alleles. After "amplifying" the DNA in this way, scientists run the alleles through an instrument that sorts the alleles and visualizes them as peaks on a chart. The positions of those peaks indicate which alleles are present — that is, they determine a person's DNA profile.

When the evidence contains plenty of DNA, those peaks are often easy to read. For example, consider a case in which a killer cuts himself on the knife he used as a weapon, leaving drops of blood at the scene. Analysts have created a DNA profile from those blood drops. In

[a]Not all mixtures are complex. For example, some but not all two-person mixtures can be relatively easy to interpret. Those mixtures would not be considered complex, and this primer does not apply to them. Also, when the evidence contains only a trace amount of DNA, it is sometimes impossible to know if that DNA came from only one individual or from multiple people. For simplicity, this primer uses the term "complex DNA mixture" to cover those cases as well.

addition, the police have arrested a suspect, collected the suspect's DNA and generated a profile from it. Here's what the two profiles might look like (**Figure 2A**).

Alleles are said to match when their peaks fall at the same left-to-right position on the chart. When comparing profiles from unrelated people, it wouldn't be unusual to find that they have a few matching alleles, just as it wouldn't be unusual to match one or two numbers in a lottery. But it would be incredibly unlikely for all the alleles to match.

It appears that the two profiles in Figure 2A match. The DNA analyst can then use well-understood statistical methods to calculate the strength of that match. This example analysis does not require much interpretation. In contrast, evidence that contains trace amounts of DNA or a DNA mixture can require more difficult interpretation.

For instance, imagine that the killer in the example case didn't cut himself and leave drops of blood at the scene. However, investigators could have recovered the knife and swabbed the handle hoping to find "touch DNA". The profiles might look like this (**Figure 2B**).

In this case, we can assume from the number of peaks that the evidence contains DNA from more than one person. The peaks are small because the amount of DNA is low. Interpreting this profile involves at least two uncertainties:

- **Uncertainity #1: When Is a Peak a Peak?** When the amount of DNA is very low, the peaks can be very small. Some peaks can be so small that they disappear entirely (they "drop out" of the profile). Also, small "blips" in the data can be mistaken for real peaks (they "drop in" to the profile). Many of these effects are random, and they can make it difficult to interpret the evidence.
- **Uncertainity #2: Whose Peak Is It Anyway?** When analyzing a DNA mixture, the alleles from all the contributors show up on the same chart. This can make it difficult to tease apart the DNA profiles of the individual contributors. To understand why this makes things complicated, recall that after amplifying the DNA, the forensic scientist has a test tube with millions of copies of the alleles in solution. Think of that test tube as a bowl of alphabet soup.

In this bowl of soup (**Figure 3A**), each letter represents a different type of allele. Our suspect is named JOHN Q SUSPECT.

We analyze the soup and find that all the letters in the suspect's name are present. Does that mean someone named JOHN Q SUSPECT contributed to the soup? Not necessarily. There could have been two contributors named PATRICK QUEEN and JUSTIN OHR (**Figure 3B**). In that case, the soup would have all the letters needed to spell JOHN Q SUSPECT, even though no person with that name contributed to the soup.

This illustrates an important point about DNA mixtures: Just because a person's alleles appear in a mixture does not mean that person contributed to it. The alleles may have come from some combination of other people who, between them, have all the allele types in the suspect's profile.

Would you like some more soup? Recall that when the amount of DNA is very small, the peaks on the chart will be small, and random effects like drop-in and drop-out become important. To continue the soup analogy, a letter can get so small that it disappears into the soup entirely. That would be drop-out. Other times, a speck of pasta might be mistaken for a real letter. That would be drop-in. Here are some ways this might affect the situation for JOHN Q SUSPECT:

Figure 2. (A) A DNA profile from crime scene evidence that contains DNA from only one individual (top) and the DNA profile taken from a suspect, often called a reference profile. These images are simplified illustrations. Real profiles would have more peaks and other details. **(B)** A profile of a low-level DNA mixture from a crime scene (top) and the DNA profile taken from a suspect. When the peaks in the evidence profile are small, they can introduce uncertainty. Did a false peak "drop in" at position A? Did a peak "drop out" at position B? To avoid prejudging the evidence, these determinations are made before looking at the reference profile (Credit: N. Hanacek/NIST).

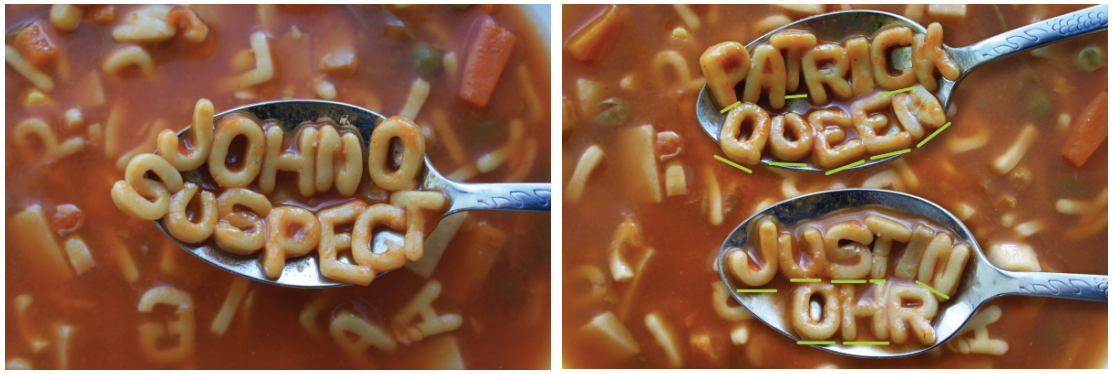

Figure 3. (A) A DNA mixture can be likened to a bowl of alphabet soup; **(B)** The letters underlined can be used to spell the name JOHN Q SUSPECT (Credit: K. Irvine, N. Hanacek/NIST).

- If the letter Q dropped out, we'd be left with JOHN SUSPECT. This evidence would be less powerful because there may be many people with that name.
- If the letter J dropped out, we'd be left with OHN Q SUSPECT. This evidence can still be quite powerful, because relatively few people have a middle name beginning with the letter Q. That letter really narrows the search.
- What if the letter Q dropped in? In that case, some innocent but unlucky person named JOHN Q SUSPECT might fall under intense suspicion.

Because of these uncertainties, it can be difficult to know whether a suspect might have contributed to a mixture. Instead of a simple yes or no, the answer is often expressed in terms of probabilities.

What Is Probabilistic Genotyping Software, and How Does It Help?

Scientists have developed computer programs to help interpret complex mixtures. Probabilistic genotyping software (PGS) uses statistical and biological models to calculate probabilities. For instance, the software is designed to account for drop-in, drop-out, and other effects by using mathematics to approximate what happens in a real mixture. PGS also considers the fact that some alleles are more common in the population than others, just as the letter J is more common in peoples' names than the letter Q.

After computing these probabilities, the software produces a number called a *likelihood ratio*. That number is the software's estimate of how much more or less likely it is to see that mixture if the suspect did contribute to it than if the suspect didn't. The jury may then take that number into account, along with other evidence, when deciding guilt or innocence.

In many cases, mixtures can be interpreted more reliably with PGS than without it, if the analyst understands the assumptions made by the software and the underlying mathematics. This makes PGS an extremely important tool, and one that can help investigators solve many crimes that might otherwise go unsolved.

However, the type of software used, how the software is configured, and which models the software runs can all affect the results. Therefore, different labs might produce different results when interpreting the same evidence. Sometimes those differences can be large enough to call into question the reproducibility of the results. This highlights the fact that every scientific method has its limits, and some mixtures will be too complex to reliably interpret even with PGS. Currently, there is no consensus on how to identify those limits.

Finally, while PGS interprets DNA profiles, it does not address an important uncertainty associated with DNA mixtures and trace DNA.

How Confident Can One Be That the DNA Is Related to the Crime?

While PGS can tell you who might have contributed DNA to a mixture, it can't tell you how or when their DNA got there. If the evidence contains a lot of DNA, this might not be a problem. For instance, investigators at the scene of a home invasion and homicide might find a broken window with blood on the glass. In that case, they might reasonably conclude that the killer broke the window to enter and cut himself on the way in. In other words, they can associate the DNA in the blood with the crime.

However, if the killer entered through an unlocked door, a swab of the doorknob might yield DNA from many innocent people who, in touching the doorknob, transferred their DNA to it. In addition, DNA can be transferred multiple times. For example, if you shake the hand of a person who later touches the doorknob, your DNA can end up on the doorknob even though you never touched it. Scientists call this "secondary transfer". Situations like these show how it can sometimes be difficult to know if trace amounts of DNA are related to the crime.

Scientists have conducted studies to better understand the factors that make DNA transfer more or less likely. They have found that some people tend to shed more

DNA than others, and some objects and materials are particularly good vehicles for transferring DNA. Still, our understanding of how, and how often, DNA transfer happens is limited.

When using high-sensitivity methods, however, forensic scientists are more likely to detect and get profiles from irrelevant DNA. That means that the risk of incorrectly associating a person with a crime has gone up in recent years. Sheila Willis, a guest researcher at the National Institute of Standards and Technology (NIST) and the former director general of Forensic Science Ireland, has commented that the risks associated with DNA transfer, when the evidence in a criminal case contains very small amounts of DNA, can be mitigated. One way to do that, she says, is to consider the totality of the evidence in the larger context of the case rather than relying solely on an isolated fragment of DNA that might not be relevant.

Should Labs Just Stop Analyzing Complex DNA Mixtures Altogether?

No. These types of samples, though often challenging, can still provide very powerful and reliable evidence. If there's one thing you take away from this primer, it should be this: Methods for interpreting DNA mixtures are not inherently reliable or unreliable. Mixtures exist on a spectrum, and the ability to reliably interpret a particular mixture depends on the specifics of the case.

The key is to ask the right questions. How complex is the mixture in terms of number of contributors and the amount of DNA from each? How confident can we be that the DNA is relevant to the case? What other types of evidence exist to corroborate the DNA evidence? Perhaps more than at any time since forensic DNA methods were invented 35 years ago, this type of critical thinking is needed.

It's also important to understand the limits of scientific methods. How far can we push new methods when interpreting complex DNA mixtures? How can we establish consistent protocols for deciding when a mixture is too complex to interpret reliably? What additional training do forensic analysts need to use new methods appropriately? NIST is conducting a study that evaluates these issues. Called "DNA Mixture Interpretation: A Scientific Foundation Review", this study evaluates the science behind these methods and identifies areas for future research. It will be published later this year.

Center for Statistics and Applications in Forensic Evidence Update

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The Center for Statistics and Applications in Forensic Evidence (CSAFE) comprises an interdisciplinary team of more than 80 researchers from four founding universities, with a recent expansion to Duke University. The team conducts research in statistical and probabilistic foundations of pattern evidence and digital evidence that can be applied to the forensics field in a variety of ways. CSAFE researchers work to build a statistically sound and scientifically solid foundation for the analysis and interpretation of forensic evidence to grow competence in the forensic sciences and legal communities, and bring together forensic practitioners and other stakeholders through educational and training opportunities. CSAFE also educates and trains forensic practitioners, legal professionals, and other stakeholders on how to use, interpret, and communicate these new methods.

The information below highlights a sample of current research and education initiatives led by the CSAFE team. Additional accomplishments in other forensic science disciplines will be discussed in subsequent issues of *Forensic Science Review*. Visit the CSAFE website *www.forensicstats.org* to learn more about the center's research and educational opportunities. CSAFE advancements are founded on strong collaborations with the forensic science community. If you would like to partner with CSAFE, please contact the team at *https://forensicstats.org/contact-2/*.

Exceptional CSAFE and NIST Partnership Earns Prestigious SPAIG Award

CSAFE and NIST received the prestigious Statistical Partnerships Among Academe, Industry, and Government (SPAIG) Award on July 30, 2018, at a special presentation in Vancouver, BC. Sponsored by the American Statistical Association (Alexandria, VA), the SPAIG award recognizes outstanding partnerships that result in significant contributions to the statistical field with applications to real-world problems. The award specifically recognized CSAFE and NIST for an exceptional partnership between academia and government organizations. Notable collaborations between CSAFE and NIST have resulted in the following

joint achievements: new automated algorithms for bullet, shoeprint, and glass comparisons that improve the accuracy of forensic analysis; creation of databases, acquisition systems, and phone apps for forensic evidence collection and quality assessment; and successful training of forensic practitioners to improve their quantitative literacy.

New Automated Mobile App Analysis Tool Improves Digital Forensics

More than 8 million mobile apps exist in today's digital world, each able to store multiple types of evidence data potentially relevant in criminal investigations. However, current standard manual analysis methods may overlook critical evidence, or may be very time-consuming. CSAFE researchers developed a new automated mobile app analysis tool, *EviHunter,* to improve efficiency, precision, and completeness of forensic investigation casework in digital evidence analysis.

CSAFE researchers investigate how evidence data flows within an app and transfer the information into the App Evidence database. This dictionary-like database includes all possible evidential data that apps generate and store on the mobile devices or remote servers. Currently, the CSAFE team focuses on Android apps. Researchers' Android app forensic analysis tool, *EviHunter,* uses program analysis approaches, enabling investigators to quickly uncover the types of evidence available, where the evidence is located, what format it is in, and other details such as a suspect's location at a certain time. Experimental results analyzing the tool on more than 100,000 apps revealed effectiveness in accuracy and coverage. Currently, researchers are able to cover more than 200 evidence types from the analyzed Android apps. This work won a best paper award at the 12th IEEE International Workshop on Systematic Approaches to Digital Forensic Engineering in May 2018 and published a paper at a top security conference – the 25th ACM Conference on Computer and Communications Security (CCS 2018) in October 2018. With this set of tools, investigators don't need expert knowledge about each app on the market. They can simply check the database to learn what types of evidence are available on the device.

CSAFE researchers are also designing Android app crawlers to collect all versions of real-world apps from over 50 app stores across the world. To date, researchers have designed and implemented seven app crawlers that can automatically download an Android application package from different app stores. Researchers plan to begin large-scale app collection to build the likely largest Android app evidence database currently available. In addition, a case study of 60 Android web-browsing apps revealed valuable evidence can be extracted from web-browsing history and Android system log messages, even though many of these apps use private (or Incognito) mode. Researchers are prototyping a tool to automatically extract evidence from these types of apps.

CSAFE Develops New Statistical Approaches to Shoeprint Analysis

The CSAFE team is developing practical statistical applications to aid crime scene investigators in the capture, transmission, and quick comparison of shoeprints. Researchers at the University of California, Irvine, are investigating statistical interpretation of shoeprint evidence by developing an observational model that takes into account partial or obscured prints. As less and less of the tread pattern is left behind, the confidence with which that impression can be matched to a specific candidate decreases. Match confidence also depends on the specifics of the tread pattern itself (e.g., is it unique to one brand of shoe or common across many?). Thus, researchers are characterizing the spatial distribution and uniqueness of tread-pattern features across a large database of shoe and brand types in order to provide statistical characterizations of match confidence based on how much and what part of a given print is visible.

To date, researchers have assembled a large dataset of shoe outsole images —the UCI Shoe Outsole Database (UCI-SHOD), collected from online retail websites — that includes ~200k images of tread patterns along with profile views and manufacturer data (e.g., brand, category). Researchers carried out evaluation of a range of image feature descriptors for use in automatically matching crime scene evidence to databases of test impressions. Researchers also developed a machine-learning–based approach for estimating the 3D shape and contact surface of a tread pattern based on photos of the tread to allow for translation of commercial imagery into pseudo-test impressions that can be used to investigate diversity of tread patterns and allow image-based search by class characteristics. Automated class-level retrieval based on crime scene impressions would allow for examiners to quickly assemble a "lineup" of candidate matches, which, in combination with statistics about the prevalence of shoe types in a locale, would provide estimates of probabilities needed for evaluating false-match probabilities.

In a second shoeprint-examination study at Iowa State University, researchers are defining a statistical score to characterize a shoeprint using 2D images that combines attributes of sole pattern, wear pattern, and randomly acquired characteristics (RACs). Researchers are investigating whether RACS are uniformly distributed in

shoe soles, or whether they follow patterns that can be used for comparisons. The CSAFE team has created a unique database of footwear outsole impressions obtained using a variety of instruments. The database includes over 30,000 images of outsoles of 160 pairs of shoes of two different makes and models and four different sizes. Measurements from each pair of shoes were obtained over a period of about six months, every six weeks, where baseline measurements were obtained when the shoes were unused. In addition to the outsole images, researchers also obtained an impression of the bottom of the feet of participants using a pressure mat, an estimate of the number of steps that were walked in the shoes between measurements, and a rough proportion of those steps that were walked on smooth floors or on various outdoor surfaces. The database is fully documented and is organized to be searchable by a variety of features including model, size, instrument, time of data collection, and any combination of those features. The database is publicly available for download on the CSAFE website data portal at: *https://forensicstats.org/longitudinalshoestudy/*.

In addition to the database, Iowa State University researchers are testing a comparison algorithm on a larger set of images obtained by using an Evrspry 2D scanner. The images correspond to a variety of shoes in a range of sizes and patterns. Each pair of shoes is scanned five times. This has enabled researchers to evaluate the current algorithm when the comparison involves two reps of the same shoe, two different shoes of the same mark and model, the most difficult type of comparison, and two shoes with different sole patterns. To carry the comparison, researchers developed an R-package called "*shoeprintr*" that implements the parallelized maximum clique algorithm for speed and efficiency. This will result in a measure of probative value of the match between two prints, contributing to increased objectivity in shoeprint-comparison methods.

CSAFE Promotes Blind Proficiency Testing Benefits to Forensic Laboratories

CSAFE research projects are developing an innovative model for proficiency testing of forensic analysts, focusing on blinding to quantify errors rates and accurately assess level of expertise. The CSAFE team focuses on building relationships with forensic laboratories interested in implementing these new methods. For example, in November 2018, CSAFE held the workshop "Blinding in Forensic Proficiency Testing and Casework" in Pittsburgh, PA. Hosted by the Allegheny County Medical Examiner's office, the event drew attendees from three primary forensic laboratory systems in Pennsylvania as well as several other states. CSAFE's new statistical approach would ensure that analysts are unaware that they are being tested, would restrict task-relevant information, and would have sample analysis include forms indistinguishable from other samples seen in everyday workflow. Blind proficiency testing can reveal not only scientific accuracy but also other aspects about how a laboratory is functioning, from workflow to customer service. CSAFE partners with the Houston Forensic Science Center in these efforts, and seeks to build collaborations with additional forensic laboratories. If your laboratory is interested in hosting a workshop to learn more about blind proficiency testing, request a training on the CSAFE website at: *https://forensicstats.org/host-a-training/*.

Visit the CSAFE Website for Webinars Addressing Diverse Forensic Science Topics

In order to expand the reach and impact of CSAFE research, the center invites the forensic science community and other scientists to participate in live public webinars focused on new forensic science research, findings, and applications. Stay up-to-date on upcoming webinars by visiting the CSAFE events page, found at: *https://forensicstats.org/events/*. Individuals not able to attend live can view recordings of past webinars any time in the CSAFE website education center at *https://forensicstats.org/forensic-scientist-education-center/*. Below are two examples of previously held webinars with available recordings.

"Probabilistic Reporting in American Criminal Cases: A Baseline Study" (Dr. Simon Cole, CSAFE researcher, University of California, Irvine); *https://forensicstats.org/portfolio-posts/probabilistic-reporting-in-american-criminal-cases-a-baseline-study/*. This webinar focused on empirical understanding of how forensic results are reported in American trials today. Forensic statisticians are advocating for the greater use of probabilistic reporting, and this webinar examines how to measure progress toward implementation.

"Covering the Basic Concepts Surrounding the Weight and Strength of Evidence" (Dr. Danica Ommen, CSAFE researcher, Iowa State University); *https://forensicstats.org/portfolio-posts/covering-the-basic-concepts-surrounding-the-weight-and-strength-of-evidence/*. This two-part presentation explores forensic identification of source problems to determine the origin of evidence with an unknown source. The researcher discusses various computational strategies for both the weight and the value of evidence and discusses recent controversies surrounding the value of evidence.

Department of Justice (DOJ) and DOJ-Sponsored Programs

Forensic Technology Center of Excellence Update: Response to Emerging Drug Threats

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RTI International (RTI) and its academic- and community-based consortium of partnerships, including its Forensic Science Education Programs Accreditation Commission partners, work to meet all tasks and objectives put forward under the National Institute of Justice (NIJ) Cooperative Agreement. This report provides a midyear update of Forensic Technology Center of Excellence (FTCoE) activities related to "emerging drug threats".

Symposia, Summits, and Forums

Rx Drug Abuse and Heroin Summit (*https://www.rx-summit.com/*). The Rx Summit, produced by Healthcare Made Practical's (HMP) Psychiatry and Behavioral Health Learning Network, was held April 22–25 in Atlanta, GA. This meeting, which began in 2012, is the largest national collaboration of professionals impacted by prescription drug abuse and heroin use. Over four days, talks covering topics including, but not limited to, advocacy, trending topics, overdose prevention strategies, and prescription practices/third party payer were presented. On Wednesday, April 24, Dr. Jeri-Ropero Miller and Dr. Hope Smiley-McDonald from RTI presented during the session titled, "Data-driven Responses to the Opioid Crisis (and Beyond)". During this session, attendees learned about efforts to enhance drug surveillance programs, upcoming efforts to help understand the needs of the death-investigation community, and the challenges faced by the death-investigation and law enforcement agencies in relation to their forensic services and performance metrics.

Webinars and Online Workshops

Three-Part Workshop Series: Best Practices Guidance for Advancing Research Initiatives and Combatting the Synthetic Drug Epidemic (*https://forensiccoe.org/webinar/best-practices-synthetic-drug-epidemic/*). The emergence of novel psychoactive substances (NPS) continue to have a major effect on laboratories. Specifically, laboratories are faced with difficulties keeping up with the most current list of emerging drugs, delays in standard reference material procurement, and interpretation of results, among other challenges. The FTCoE, in association with the Center for Forensic Science Research and Education (CFSRE), delivered a three-part online series of presentations providing insight into the challenges faced by forensic laboratories with respect to analysis and interpretation of findings involving NPS. There were over 200 attendees online during each live session, which took place on July 17, 18, and 25 (2018). The topics covered during these sessions included the following:

- Session I: *The Synthetic Drug Crisis - Identifying NPS in Forensic Casework*
- Session II: *Analysis of NPS: Practical Considerations and Analytical Approaches*
- Session III: *Interpretative Toxicology for NPS in Forensic Casework*

A total of 17 presentations were given by scientists from various laboratories and institutions such as NMS Labs, CFSRE, DEA Southwest Laboratory, and the Knox County Medical Examiner.

Identifying Seized Drugs Using Mass Spectral Library Searching (*https://forensiccoe.org/webinar/seized-drugs-mass-spectral-library/*). The rapid spread of designer drugs has introduced significant identification challenges to the forensic science community. Mass spectral library searching is an important tool in seized drug identification. It allows an analyst to identify a drug by comparing the experimental spectrum to a reference set of spectra for known compounds. Arun Moorthy, from the National Institute of Standards and Technology (NIST) Mass Spectrometry Data Center (MSDC) and Gary Mallard, formerly of NIST, presented on conventional library searching and the new "Hybrid Search" method that combines fragment-ion and neutral-loss matching when computing similarity match factors. This live event, held August 7, 2018, was delivered to a total of 279 attendees. Learning objectives were:

- Broadly explain the principles of mass spectral library searching and uncertainty involved with search-based identification.
- Understand the limitations of conventional mass spectral library searching for novel compounds such as designer opioids.
- Apply the "Hybrid" mass spectral library search method for compound classification.

Novel Forensic Chemistry Research from Early-Career Scientists (*https://forensiccoe.org/webinar/forensic-chemistry-research-early-career-scientists/***).** National

Forensic Science Week recognizes the contributions that forensic science makes to the criminal justice system. In 2018, the FTCoE held a webinar showcasing novel projects of early-career scientists, with themes including toxicology, opioids, and NPS. This live event, held September 19, 2018, was attended by a total of 42 individuals with topics that included, but not limited to, the following:

- Use of a LC-QTOF Assay for the discovery of emerging NPS
- Stability of synthetic cathinones in blood using LC/Q-TOF-MS
- Segmental analysis of GHB in human head hair

Emerging Forensic Research Series: Toxicology and Drugs (*https://forensiccoe.org/webinar/rd-webinar-series-emerging-forensic-research/*). The goal of this webinar series was to disseminate novel research that is being completed within the forensic community. The fourth webinar in the Emerging Forensic Research webinar series, Forensic Toxicology and Drugs, covered the following topics:

- Development and validation of a novel blood protein modification assay for retrospective detection of drug exposure
- Retrospective identification of synthetic cannabinoids using archived high-resolution mass spectrometry data
- Development of matrix-matched quality-control materials and sample-preparation techniques for the analysis of marijuana-infused products
- Coupling Raman spectroscopy with ambient sampling, portable mass spectrometry for on-site, high-throughput evidence confirmation

This series, which took place April 23, 2019, consisted of a brief overview of each topic followed by a Q&A session.

Just Science Podcast

The Center for Forensic Sciences at RTI produces a podcast series, funded in part by the FTCoE and hosted by Dr. John Morgan, called *Just Science*. This podcast series represents a concerted effort involving community, industry, and discipline leaders to disseminate research and real-world practice to a wide audience — sparking conversations and innovations within the field. *Just Science* explores new technologies and systems that provide more efficient ways of delivering quantitative results and the human factors that go into producing solid data. Since its launch in May 2017, the FTCoE has hosted a total of 94 episodes, 11 complete seasons, with 4 special-release seasons. *Just Science* can be found on iTunes, Google Play, Stitcher, and SoundCloud.

Just Field Identification Drug Officer-Episode 42 (*https://forensiccoe.org/js4-e1/*). Nancy Crump, an assistant crime laboratory administrator at the Phoenix Police Department, discusses the creation of the Field Identification Drug Officer program and how the lack of laboratory resources creates an inefficient system for testing drugs found in the field and possible solutions for this issue.

Just Drug Courts-Episode 43 (*https://forensiccoe.org/js4-e2/*). Drug courts are one of the many tools the Department of Justice is using to combat overcrowded prisons and dangerous drug addictions. Preeti Menon, the senior associate director at the Justice Programs Office center in the School of Public Affairs at American University, discussed how drug courts are improving the justice system and how American University is contributing in the fight against addiction.

Just Electronic Dance Music Festivals-Episode 44 (*https://forensiccoe.org/js4-e3/*). Research scientist Alex Krotulski and forensic scientist Amanda Mohr at the CFSRE discuss their NIJ-funded research titled "Evaluating Trends in Novel Psychoactive Substances Using a Sentinel Population of Electronic Dance Music Festival Attendees".

Just Liver Die-Episode 45 (*https://forensiccoe.org/js4-e4/*). Dr. Carl Wolf, from the Medical College of Virginia Commonwealth University, discussed his NIJ-funded research, titled "Liver Doesn't DIE, or at least its Enzymes, and Other Useful Information Discovered while Evaluating the Effect of Sample Preparation Techniques on Matrix Effects and Absolute Recovery of Opiates in Liver Tissue using UPLC-MS/MS."

Just Doobious Driving Drugs-Episode 46 (*https://forensiccoe.org/js4-e5/*). Colorado's recreational marijuana legalization traffic experts Jennifer Knudsen, from Colorado's Traffic Safety Resource Prosecutor, and Glenn Davis, from the Highway Safety Manager for the Colorado Department of Transportation, discussed the law and operations of the existence of recreational marijuana and its impact on the transportation sector.

Just Chasing the E-Cig Dragon-Episode 50 (*https://forensiccoe.org/js4-e8/*). Dr. Michelle Peace, from Virginia Commonwealth University, discussed her research in the area of E-cigarettes, which has gained popularity in recent years.

Just Solving the Opioid Crisis-Episode 51 (*https://forensiccoe.org/js4-e9/*). RTI International's Dr. Gary Zarkin and Dr. Jeri Ropero-Miller discussed the US opioid epidemic, from its history and origins, to strategies for prevention and treatment.

Just Opioid Financial Burden on Crime Labs-Episode 54 (*https://forensiccoe.org/js4-e12/*). It is estimated that crime labs spend approximately $270 million a year just on the opioid crisis. Dr. Paul Speaker, from West Virginia University, discussed the economic burden the justice system has from opioid deaths.

Just Portable Mass Spectrometer Possibilities-Episode 60 (*https://forensiccoe.org/js5-e5/*). Dr. Jamie R. Weiland and Dr. Christopher Mulligan of Illinois State University discussed the impact of implementing portable mass spectrometers for on-site drug evidence processing.

Just Throwing DARTS at the Opioid Crisis-Episode 83 (*https://forensiccoe.org/js7-e7/*). Amber Burns, Chemistry Section manager for the Maryland State Police Department, discusses her team's work in using Direct Analysis in Real Time (DART) Mass Spectrometry to detect fentanyl and other chemicals in recovered samples.

National Forensic Laboratory Information System Update: Overview of Recent Findings, Summary of Expansion Plans, and Future Directions

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The National Forensic Laboratory Information System (NFLIS) is a Drug Enforcement Administration (DEA) program that systematically collects results of forensic analyses and other related information from local, regional, and national entities. The program consists of three components (NFLIS-Drug, NFLIS-Tox, and NFLIS-MEC) that will eventually complement each other to provide a holistic picture of the drugs analyzed by the US forensic community when the newly established NFLIS-Tox and NFLIS-MEC programs have reportable data [1].

NFLIS began in September 1997 as a single data-collection effort of drug chemistry analysis results from local, state, and federal forensic laboratories (now called NFLIS-Drug). These laboratories analyze substances secured in law enforcement operations across the country. NFLIS-Drug is an operational information system that includes data from forensic laboratories that conduct analyses of about 98% of the nation's approximately 1.5 million annual drug cases. NFLIS-Drug is a voluntary program that includes 50 state systems and 104 local or municipal laboratories and laboratory systems, representing a total of 282 individual laboratories. NFLIS-Drug offers a valuable resource for monitoring illegal drug abuse and trafficking, including the diversion of legally manufactured pharmaceutical drugs into illegal markets. NFLIS-Drug data are used to support drug regulatory and scheduling efforts and to inform drug policy and drug enforcement initiatives nationally and in local communities.

In 2019, the DEA expanded the NFLIS program to include (a) public and private toxicology laboratory (NFLIS-Tox) data regarding postmortem and antemortem toxicological testing and (b) medical examiner and coroner office (NFLIS-MEC) data regarding deaths in which drugs were identified. Once the two new continuous data-collection programs have matured enough to support regular reporting, they will complement the NFLIS-Drug component and further support the DEA's drug regulatory and scheduling efforts. In February 2019, the DEA began actively recruiting voluntary participants in these two NFLIS expansion programs. NFLIS-Tox and NFLIS-MEC members initiate their participation by signing Memoranda of Understanding (MOUs) with the DEA. More information about the NFLIS components and becoming a participant can be found in the *Frequently Asked Questions* document on the NFLIS website [2]. As more participants join NFLIS-Tox and NFLIS-MEC, aggregated data will be publicly available in midyear, annual, and special reports, as well as peer-reviewed manuscripts similar to the reports offered by the NFLIS-Drug component. Additionally, participants will have access to a secure component-specific portion of the NFLIS website called the Data Query System (DQS) [3].

In the past year, several new reports have been published on DEA's NFLIS website across all three components of the NFLIS program (*https://www.nflis.deadiversion.usdoj.gov/Reports.aspx*). Most recently, in April 2019, NFLIS published the *NFLIS-Drug Special Report: Methamphetamine Reported in NFLIS, 2001–2017* [4] and the *NFLIS-Drug 2018 Midyear Report* [5]. From 2001 to 2017, national annual estimates of reports of methamphetamine increased 83%, and methamphetamine is currently the number one reported substance in NFLIS-Drug. The NFLIS-Drug methamphetamine special report dives deeper into specific NFLIS-Drug details regarding methamphetamine, including information on methamphetamine purity and methamphetamine reports by state and county. The report also compares regional trends regarding methamphetamine, heroin, cocaine, and

cannabis/THC and provides a complete picture of their reporting to NFLIS-Drug from January 1, 2001 through December 31, 2017.

The 2018 NFLIS-Drug midyear report presents results of drug cases submitted to state and local laboratories from January 1, 2018, through June 30, 2018, that were analyzed by September 30, 2018. The report includes data on national and regional trends of the top 25 most frequently encountered drugs and data on specific drug categories, including narcotic analgesics, tranquilizers and depressants, and synthetic cannabinoids. According to the 2018 midyear report, fentanyl accounted for 43% of narcotic analgesic reports, and alprazolam accounted for 59% of tranquilizer and depressant reports. Among identified synthetic cannabinoids, 5F-ADB and FUB-AMB accounted for 67% of the reports [5].

In the fall of 2018, DEA published findings from the *2017 Medical Examiner/Coroner Office Survey Report* [6], and the *2017 Toxicology Laboratory Survey Report* [7] highlighting key information about medical examiner and coroner office (MEC) and toxicology laboratory operations, caseloads, accreditations, policies, and practices across the US. Of the MEC respondents, 38% indicated that all of the specific drugs would be listed on the death certificate in cases where a drug is found as a cause or contributing cause of death [6]. Of MEC respondents, 32% characterized their records-management system as a computerized, networked system compared with 78% of toxicology laboratories [7]. The survey reports did not include all of the information from each survey, such as more details on toxicology testing practices, because this information will be a focus of upcoming NFLIS-MEC and NFLIS-Tox reports.

Finally, in April 2019, the DEA began administering its sixth iteration of the NFLIS-Drug Survey of Crime Laboratory Drug Chemistry Sections. The survey gathers information on laboratory administrative procedures, drug chemistry caseload, types of analytical instruments used, frequency of testing and quantitative analyses across drugs and drug classes, and practices regarding the testing of emerging drugs. Aggregated information from this survey will be published toward the end of 2019 and will update the findings previously published in the *2013 Survey of Crime Laboratory Drug Chemistry Sections* [8].

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NEW BOOKS AND BOOK REVIEW

New Forensic Science Books

Age Estimation: A Multidisciplinary Approach

J. Adserias-Garriga, Ed
Academic Press/Elsevier: Waltham, MA, US; 2019

Chemical Warfare Agents: Biomedical and Psychological Effects, Medical Countermeasures, and Emergency Response, 3rd ed

B. J. Lukey, J. A. Romano Jr., H. Salem
CRC Press: Boca Raton, FL, US; 2019

Death, Decomposition, and Detector Dogs: From Science to Scene

S. M. Stejskal
CRC Press: Boca Raton, FL, US; 2019

Essential Forensic Biology, 3rd ed

A. Gunn
Wiley-Blackwell: Somerset, NJ, US; 2019

Forensic Aspects of Hypoglycaemia

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

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

S. Bell
CRC Press: Boca Raton, FL, US; 2019

Fraud Auditing Using CAATT: A Manual for Auditors and Forensic Accountants to Detect Organizational Fraud

S. Aghili
CRC Press: Boca Raton, FL, US; 2019

Introduction to Forensic Science and Criminalistics, 2nd ed

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

Introduction to Pharmaceutical Analytical Chemistry**,** 2nd ed

S. Pedersen-Bjergaard, B. Gammelgaard, T. G. Halvorsen
Wiley-Blackwell: Somerset, NJ, US; 2019

Ortner's Identification of Pathological Conditions in Human Skeletal Remains, 3rd ed

J. E. Buikstra, Ed
Academic Press/Elsevier: Waltham, MA, US; 2019

Postmortem Toxicology: Challenges and Interpretive Considerations

T. Rohrig
Academic Press/Elsevier: Waltham, MA, US; 2019

Practical Military Ordnance Identification**,** 2nd ed

T. Gersbeck
CRC Press: Boca Raton, FL, US; 2019

Practicing Forensic Criminology

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

Principles of Forensic Engineering Applied to Industrial Accidents

L. Fiorentini, L. Marmo
Wiley-Blackwell: Somerset, NJ, US; 2019

The Expert Witness, Forensic Science, and the Criminal Justice Systems of the UK

S. L. Hackman, F. Raitt, S. Black
CRC Press: Boca Raton, FL, US; 2019

The Future of Forensic Science

D. A. Martell, Ed; D. H. Ubelaker, Series Ed.
Wiley-Blackwell: Somerset, NJ, US; 2019

The Goddard Guide to Arthropods of Medical Importance, 7th ed

G. M. Moraru, J. Goddard II
CRC Press: Boca Raton, FL, US; 2019

Book Review

Practical Crime Scene Processing and Investigation, 3rd ed

Ross M. Gardner, Donna R. Krouskup
CRC Press: Boca Raton, FL, US; 2018

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Practical Crime Scene Processing and Investigation, 3rd ed, is a comprehensive resource for crime scene investigators, crime scene trainees, students, and other professionals within the forensic science community. The book provides its readers with valuable information regarding physical evidence, the actions that an investigator should take at a scene, processing techniques and methodologies, and other scene considerations.

The authors, Ross M. Gardner and Donna R. Krouskup, both have a considerable amount of experience in the field, which translates into a book that is practical and up-to-date. Mr. Gardner worked as a felony criminal investigator for the US Army Criminal Investigation Command (USACIDC) for 24 years and as the chief of police for the city of Lake City, GA, for 4 years. Ms. Krouskup currently works for the Denton Police Department in Denton, TX. She spent 4 years as a communications officer in the dispatch center and the past 10 years as a crime scene investigator (CSI).

This 398-page book consists of 16 chapters, three appendices, and multiple figures and real case examples. Case examples demonstrate the topics previously discussed in the chapter and highlight best practices and mistakes to avoid. Review questions and additional resources are also provided at the end of each chapter. The questions reinforce the content from each chapter and can be particularly useful when preparing for competency tests and certification exams. The additional resources are valuable for those seeking more knowledge on a particular subject. For example, Chapter 14 is titled "Special Scene Considerations" and discusses unusual or complicated scenes such as fire investigations, scattered or buried remains, and landfill body recoveries. The information provided within the chapter provides a foundation for these topics, but the resources listed at the end of the chapter provide more in-depth reading options.

The book begins with an introduction (Chapter 1) that covers the purpose of crime scene processing, scene integrity issues, and investigative ethics. Chapter

2 discusses physical evidence and provides a basic introduction to different types of evidence that a CSI may encounter at a scene, such as fingerprints, trace evidence, firearm and toolmarks, biological evidence, chemical evidence, and more. These two chapters provide a foundation for the content presented in the rest of the book.

Chapters 3 and 4 discuss the actions of the initial responding officer and processing methodology, respectively. An adapted USACIDC processing model is introduced that consists of 17 steps from the initial notification to packaging evidence and conducting a debriefing. The authors provide this methodology to ensure that a CSI approaches and documents a crime scene effectively, which can be especially useful on a large or complex scene. Chapter 5 describes scene assessment including search considerations, search patterns, personal protective measures, and considerations for mass crime scene and mass casualty situations.

Chapters 6 through 8 focus on documentation procedures: basic crime scene photography, sketching and mapping, and notes/reports. A new section about 3-D laser mapping has been added to this edition to replace the section on Scan Station mapping in the second edition, which was published in 2011. This section introduces a technology that is now more commonly used in the field and discusses its value and purchasing considerations.

Other topics covered throughout the book include light technology, fingerprint evidence, impression evidence, shooting scene reconstruction, bloodstain pattern analysis, and the role of crime scene analysis and reconstruction. The fundamental information provided in these sections guides even a novice crime scene investigator to competently and thoroughly investigate a scene.

As a current crime scene trainee, I have found this book to be very useful in supplementing my in-house training and field experience. The book is extremely easy to navigate, and I have been able to quickly find answers to any questions that I have. Additionally, the case examples reinforced the content discussed in the chapters and reminded me to consider all scenarios when I am at a scene. As a visual learner, I found the figures to be extremely effective in relaying the concepts discussed. For example, in Chapter 2, there was a section that discussed glass and determining the direction of force for broken glass panes—the figure therein effectively demonstrated how to locate radial and concentric fractures. Without this figure, I would not have been able to grasp the concept as easily.

Overall, this book is a resource that is well suited to complement training courses, workshops, and an agency's protocols and standard operating procedures. It is written at a level that is technical enough to be a reference for those actively working in the field, but it is also a great introductory book for those who know little about crime scene investigation. Although no two crime scenes are the same, the authors present a book that covers numerous aspects of the investigation to ensure that a CSI carefully considers what types of evidence may be present and how to confidently process the scene.

TEITELBAUM'S COLUMN ON FORENSIC SCIENCE — HISTORICAL PERSPECTIVE —

Some Firsts from the Early Years of Drunk Driving

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Given the laudable profiles of the researchers who are providing the technical articles in this themed issue, I will let them do the heavy lifting while I try to provide some confetti from the sidelines. In his profiles, histories, and research articles, Wayne Jones alone has thoroughly covered every possible topic that I came up with in an effort to write something related to the history of intoxicated and/or drugged driving. So my contribution for this issue will be to simply list some of the events that surprised me as I researched this topic.

First Recorded Automobile Death

The world's first recorded automobile death apparently occurred on August 31, 1869, in Ireland [1]. Mary Ward was riding as a passenger in an experimental steam car in the town of Birr, but she was thrown from the car and fell underneath the wheels of the car. Ward was a scientist and the author of six books (most of them dealing with microscopy). Ireland's Black Flag Act of 1865 set the speed limit for cars at 2 mph in towns, but homemade cars, like the one Ward's cousins had built, could let loose at speeds over 4 mph outside town, and this is where Ward's fatal accident occurred.

First Person Arrested for Drunk Driving

The person acknowledged as the very first person to be arrested for drunk driving was a 25-year-old London taxi driver named George Smith [2]. At 1:00 am on September

10, 1897, Smith slammed his cab into a building, later admitting that he had had several drinks, and had been arrested before for intoxication, but that this was the first time he had been charged with being drunk while driving a cab. He was fined 20 shillings.

First American Gasoline-Powered Auto Accident

In 1891, Ohio inventor John W. Lambert built the first American gasoline-powered automobile (**Figure 1**). He was also involved in the first automobile accident in American history. While Lambert was driving his automobile, the vehicle hit a tree root, causing the car to veer out of control and smash into a hitching post.

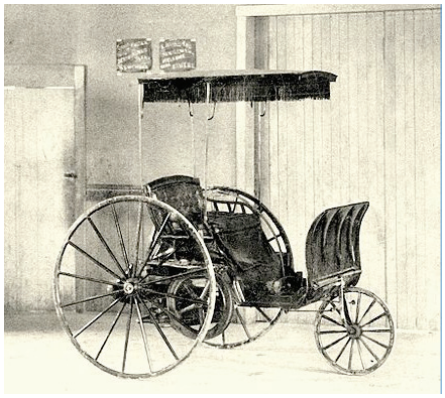

Figure 1. Lambert's first American gasoline automobile Figure is for open access; *https://commons.wikimedia.org/wiki/File:First_American_Gasoline_Automobile.jpg* (Accessed May 28, 2019).

First Person Killed by a Gas-Powered Motor Car

On August 17, 1896, Bridget Driscoll became the first person to be killed by a gasoline-powered motor car. As she was crossing the grounds of the Crystal Palace in Hyde Park, London, she was hit by an automobile belonging to the Anglo-French Motor Carriage Company that was being used to give demonstration rides. Although the vehicle was capable of speeds up to 8 mph, the driver claimed he had only been going 4 mph.

First American Fatally Struck by an Automobile

The first person to be killed by an automobile in the US was Henry Bliss, when (on September 13, 1899) an electric-powered taxicab struck him. His head and chest were crushed, and he died the following morning.
On August 6, 1915, 9-year-old Douglas Spedden (a survivor of the Titanic sinking three years earlier) was fatally struck by an automobile at his family's winter home in Maine.

First US State To Ban Drunk Driving

In 1906, New Jersey became the first state in the US to pass a statute banning drunk driving [3]. The entire statute read: "*No intoxicated person shall drive a motor vehicle*." New York followed with its own ban in 1910.

First Alcohol Breath Test Developed by McNally in 1927

Before Robert Borkenstein invented the breathalyzer in 1954, and even before Rolla Harger invented the Drunkometer in 1938, W.D. McNally developed the first alcohol breath test in 1927 [4]. McNally was a chemist and toxicologist for the Cook County Medical Examiner's office in Illinois, and he created an apparatus (**Figure 2**) where, by breathing into a tube, the chemicals in the container would change color if the slightest trace of alcohol were present. McNally never developed the device commercially.

Figure 2. Tests a tippler's breath. Figure courtesy of *Popular Science Monthly*.

First Use of a Gun to Determine the Effects of Alcohol on Driving

Some of the early tests to determine the effects of alcohol on driving would possibly not receive government approval today. From a 1932 study conducted by Heise and Halporn: "*In order to gain further information, a practical test was devised involving actual driving conditions. A car was rigged up so that shooting a gun would give the signal to apply the brakes, and this in turn would shoot another gun. The knowledge of the speed of the car and the distance apart of the bullet marks on the road furnished a means of measuring reaction time."* [5]

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COMMENTARY

Alcohol, Drugs, and Highway Safety: The Robert F. Borkenstein Courses on Alcohol and Other Drugs*

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Patrick Harding retired as supervisor of the Toxicology Section of the Wisconsin State Laboratory of Hygiene (WSLH) in 2012 after 35 years of service. For more than 30 years Patrick functioned there as a technical expert in blood and breath alcohol testing, providing training and testimony (in over 750 trials). Patrick has been on the faculty of the Robert F. Borkenstein Course on Alcohol and Highway Safety since 2002 and is currently its Associate Director, as well as for the Borkenstein Course on Drugs.

Patrick is a former chair of the National Safety Council Committee on Alcohol and Other Drugs, on the Board of Directors of the International Association for Chemical Testing, a member of the Canadian Society of Forensic Science Alcohol Test Committee, a member of the Society of Forensic Toxicologists and a Fellow of the American Academy of Forensic Sciences. He has co-authored papers on breath and blood alcohol testing and co-authored a breath alcohol testing chapter in Medicolegal Aspects of Alcohol, as well as a special topic monograph for American Prosecutors Research Institute entitled "Alcohol Toxicology for Prosecutors".

Patrick has been recognized for his professional contributions to forensic toxicology and highway safety, having received IACT's Kurt M. Dubowski Award (2005), The NSC Robert F. Borkenstein Award (2007) and the AAFS Toxicology Section Ray Abernethy Award (2013).

The Robert F. Borkenstein Course on Alcohol and Highway Safety: Testing, Research, and Litigation (the Alcohol Course) celebrated its 60th anniversary in 2018. The course, founded by Prof. Borkenstein at Indiana University in 1958, has met the educational and training needs for those engaged in alcohol testing activities for generations of students, some 6,000+ to date. During this time, it has become an integral part of personnel training protocols for countless forensic breath and blood-alcohol programs and laboratories in the US and Canada, and has attendees from many other countries. Since 2002 a companion course, The Robert F. Borkenstein Course on the Effects of Drugs on Human Behavior (the Drugs Course), founded by Executive Director Dr. Barry K. Logan, has reached similar stature for those involved in drugs and highway safety.

A Brief History

The Breathalyzer, patented in 1954 by Robert F. Borkenstein, improved upon existing breath-testing methods and revolutionized the investigation of alcohol-impaired driving offenses. Police officers would now be able to reliably and accurately determine a driver's alcohol concentration without the need of sending samples to a laboratory. The introduction of the Breathalyzer in the US and Canada created a greater demand for training operators and establishing testing programs. When Prof. Borkenstein became the chair of the Indiana University (IU) Department of Police Administration in 1958, he took on the task of establishing a short course targeting breath-alcohol testing instructors, technicians, supervisors, and administrators to help meet this need. The result of this was the first Supervision of Tests for Alcohol course in 1958. Prof. Borkenstein went on to establish the Center for Studies of Law in Action in 1970, associated with what is now the IU Department of Criminal Justice. One of the functions of the Center was to continue the administration of the Alcohol Course, a role that continues to this day under Executive Director Dr. Barry Logan and Director Dr. Kip Schlegel of the IU Department of Criminal Justice.

A faculty member for over 50 years, Dr. Kurt Dubowski (November 21, 1921–October 23, 2017), best described the basis of the course: "The Alcohol Course philosophy was established by Prof. Borkenstein and the initial core faculty as emphasizing the "why" of the program and procedural elements of forensic breath-alcohol testing in addition to the "how", being scientifically rigorous and comprehensive, and highly interactive among and between course registrants and faculty, and between the regular faculty members and guest lecturers" [1]. Prof. Borkenstein's selection criterion for faculty and guest lecturers was simple: "The best-of-the-best academic scientists and active practitioners in their

*This article is dedicated to the memory of Kurt M. Dubowski, Ph.D., DABFT, who served on the faculty of the Alcohol Course for more than 50 years.

respective professions (chemistry, law, law enforcement, pharmacology, toxicology, etc. …" [1]. These core tenets have remained as the foundation for the course as it has evolved over the years and have continued under the leadership of Dr. Barry Logan.

Evolution of the Alcohol Course

The original target audience for the class has expanded as the course has progressed. During the first decades of the course, attendees were almost exclusively males who were primarily associated with law enforcement agencies. Accreditation (of testing programs and breath-test calibration laboratories) and an increase in blood-alcohol testing (as opposed to breath testing) have fundamentally altered the makeup of the class. Recent classes have fewer attendees that are solely involved in breath-alcohol testing. The majority of the students now comprises forensic scientists and criminalists working in laboratories that perform blood-alcohol testing, with half or more of the class being females. Course attendees include breath-test instrument manufacturers and maintenance technicians; blood-alcohol analysts in forensic, public health, and postmortem labs; individuals who interpret alcohol test results; Standardized Field Sobriety Test instructors; Drug Recognition Experts (DREs); Ignition Interlock-related personnel; prosecutors; consultants; and to the extent possible, the defense bar. We also find that many students have little or no experience testifying in court. In order to address all these changes, the course has added instruction in blood-alcohol testing, expert testimony, accreditation/certification, and most recently a moot court demonstration, among other topics.

To ensure that the course remains responsive, students are urged, some might even say nagged, to fill out course surveys after each presentation. These surveys are reviewed by course administrators and faculty to assess how well the course addresses student needs and expectations.

The Drug Course

The increasing awareness of the scope and impact of drugs other than alcohol on highway safety created a need for specialized training and education not available elsewhere. The Robert F. Borkenstein Course on the Effects of Drugs on Human Behavior (the Drugs Course) was first presented in March 2002. Dr. Barry Logan modeled this course on the same core tenets and principles as the well-established and successful Alcohol Course. It is designed as an expert-level course that supplements existing workshops and scientific sessions offered by organizations such the Society of Forensic Toxicologists, Inc. and the American Academy of Forensic Sciences. The course includes an overview of the scope of the drug-impaired driving problem, as well as the law enforcement, legislative, legal, and toxicological challenges in addressing the problem. Drugs and groups of drugs found in driving-impairment cases, such as cannabinoids, benzodiazepines, opioids, cocaine, and methamphetamine, CNS depressants, and others are covered in the course with the underlying pharmacological basis for their effects, on-road driving studies, and toxicological aspects in casework. How this complicated information gets presented to courts is covered through presentations from prosecutors, defense attorneys, and toxicologists, as well as a moot court breakout session for DREs. Additional topics of current interest are added as the need arises, such as the impact of Canada's legalization of marijuana and recommended laboratory guidelines for scope of testing in drug-impaired driving cases. As with the Alcohol Course, students are asked to evaluate the class and its faculty and provide feedback on course topics.

Summary

Robert F. Borkenstein was a remarkable man who had a career and life full of accomplishment and dedicated service, which had a lasting impact on individuals, organizations, and institutions involved in highway safety [2]. The course he founded more than 60 years ago may well be his greatest legacy, having influenced and inspired thousands of forensic scientists, law enforcement officers, researchers, academicians, policy makers, and others in the field. His international stature and devotion to highway safety attracted other accomplished individuals to enthusiastically participate as course faculty and to be part of his endeavor. Under Dr. Logan's direction both courses that now bear the Robert F. Borkenstein name continue to attract qualified faculty who relish the opportunity to participate in the courses and interact with the students and other faculty. Most importantly, the model created by Prof. Borkenstein to provide students with the best and most up-to-date information, provided by a world-class faculty in an interactive environment, will continue to serve the needs of the forensic community for many years to come.

The Professor would be proud!

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