2025 Global Forensic Science Symposium

Abstracts

FIU | Global Forensic and Justice Center
Florida International University

Miami, Florida, United States of America

June 3-5, 2025

A Crime Scene is a Space, Not a Place

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A place is a physical location with a history, while a space is an imagined or virtual location. A crime scene is a place altered by criminal activity, becoming a complex space. It embodies both the normal environment and the superimposed criminal environment. The investigator must deal with the totality of information, mundane and forensic, to make sense of the scene.

The agency of those involved at the crime scene convert the mundane into the forensic. The forensic proxy data, like DNA or fingerprints, encode the events at the scene and becomes evidence; not all mundane items become forensic and not all forensic items are recognized or recovered. The crime scene is an analytical space where evidence is the outcome of past events and the investigator's actions. The investigator's perception and interaction with the scene create the conditions for evidence to be meaningful, making the scene dependent on and interactive with the investigator. Crime scenes are defined analytical spaces with explicit rules about their processing and the recognition, recording, and recovery of any evidence.

Processing a crime scene is not just collecting items; it involves defining and securing the scene to "freeze time." This includes recording the scene's condition and status, recognizing potential evidence, and recovering items. The investigator must redefine their perspective of what is meaningful, considering the relationships between items and the space. A crime scene can only be processed once, as any return results in a "new" scene. Therefore, recording preserves information in time and space and prevents contamination, ensuring the future scientific and interpretive value of the recovered evidence.

Adaptation of Common Ammunitions For Available Firearms in Sri Lanka and Challenges For Experts In Crime Investigation

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In Sri Lanka, the public's possession of firearms is strictly prohibited under law. However, following the conclusion of the civil war, there has been a significant proliferation of weapons and ammunition across the country, often remaining in illegal circulation. In many cases, individuals engaged in illegal activities with firearms do not replace their weapons to match the ammunition available, as this reduces the firearm's value or involves additional logistical

challenges. Instead, they adapt the available ammunition to fit their existing firearms, sometimes employing rudimentary modifications or dangerous improvisations. This practice complicates law enforcement and investigations.

The adaptation of ammunition to mismatched firearms is a widespread and pressing issue in the investigation of firearms-related crimes. These adaptations or modifications pose significant challenges for firearm experts, especially in comparison of tool marks on the crime spent cases with test spent, as the tool marks left on refilled cartridges are often double-impressed or damaged, mismatched calibers with spent cases in the absence of fabricated sleeves, unusual tool marks on modified or hammered ammunition, and altered cartridges produce unusual and inconsistent tool marks. An expert must possess extensive knowledge of these adaptations or modifications and their mechanisms to analyze evidence accurately and avoid being misled by the apparent mismatches. A thorough understanding of tool marks, firearm mechanisms, and improvised modifications is essential for handling such cases. This expertise is crucial in overcoming the challenges posed by adapted ammunition and ensuring the integrity of firearm-related crime investigations.

Applied Biosystems™ RAPIDINTEL™ PLUS Cartridge: Validation For Investigative Leads

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Although DNA profiles from reference samples run on rapid DNA instruments are allowed into CODIS, the Federal Bureau of Investigation (FBI) does not currently allow upload of DNA profiles from crime scene samples run on rapid DNA instruments. In 2020, the Scientific Working Group on DNA Analysis Methods (SWGDAM), European Network of Forensic Science Institutes (ENFSI), and the FBI Rapid DNA Crime Scene Technology Advancement Task Group outlined rapid DNA requirements that, when met, would allow DNA profiles from crime scene samples run on rapid DNA instruments to be uploaded into CODIS. In 2024, Thermo Fisher Scientific released a new sample cartridge for the RapidHIT™ ID System, the RapidINTEL Plus sample cartridge, designed to meet these requirements while improving on the performance of crime scene samples run on the RapidHIT ID system. The RapidINTEL Plus sample cartridge was developed in conjunction with the RapidHIT ID System Software v2.0 and RapidLINK™ Software v2.0. In addition to new features required for CODIS eligibility, improvements made to the RapidINTEL Plus cartridge produce high quality, complete, and consistent data from crime scene samples through the introduction of Internal Quality Control markers, Quantification markers, and PCR enhancements to increase sensitivity and improve peak height and inter-locus balance. We performed a developmental validation to assess the newly optimized RapidHIT ID System v2.0 for the analysis of investigative lead samples with our RapidINTEL Plus cartridge. The system demonstrated a substantial improvement in first pass success and sensitivity with mock case samples, and suitability for law enforcement personnel to generate investigative leads and identify suspects faster. The system also meets the upcoming Quality Assurance standards put forth by SWGDAM.

Autonomous Detection Systems

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High-risk field detection and exploitation applications are driving a need for autonomous detection systems. Where traditionally, operators and canines would be used; land, sea, and air-based robots may now be deployed. New networked robotic systems may provide highly sophisticated real-time data acquisition capabilities for reconnaissance and situational awareness. These capabilities may include spatial and environmental mapping along with application specific sensing for reduced risk to field operators, as well as simple static monitoring. As sensor technology advances new detection systems reduce in size, weight, and power, increasing their compatibility as payloads for autonomous robotic platforms, opening paths to new and reduced risk detection applications. A typical application could be the deployment of a robotic dog (dogbot) with environmental and chemical sensors for the exploitation of a suspected release of a chemical agent in a populated area. Where the dogbot would map the extents of the detected chemical plume and overlay that data on the spatial area map. Additionally, localized wind direction and speed data would be included for plume migration assessment for evacuation purposes. While robotic sensing applications are increasingly routine the advancement of new detector systems and robotic platforms is enabling new end-point detection not previously possible. These detectors include new sub 5-kilogram stand-off laser detection systems, electro-chemical gas and other sensors, and contact sampling methods for field exploitation. New autonomous detection systems are highly sophisticated and require a high level of collaboration in their development to application and field implementation. Multidisciplinary collaborations across the fields of chemistry, engineering, computer science, and environmental sciences are all needed to realize these new autonomous detection systems to advance end point detection in forensic science. Current developments and capabilities of The FIU Center for Autonomous Detection Systems will be presented.

Breaking the Ice on Cold Cases, and Igniting Interest in IGG: How to Build Law Enforcement Relationships Through Mutual Understanding

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Since 2018, the use of Investigative Genetic Genealogy (IGG) has become a popular tool to aid in law enforcement investigations involving unknown perpetrators, and unidentified human remains cases. While the use of IGG as an investigative tool has continued to rise in popularity, the desire for people to seek employment as IGG practitioners has also risen. This increase in popularity has created a desirable space within the realm of criminal justice, where genealogy enthusiasts, web-sleuths, and average citizens with a flair for research, can often help solve crimes, and identify the nameless.

For people seeking employment or contract work within the field of IGG, the ability to create rapport and build relationships with a customer base consisting largely of law enforcement

investigators, is a vital yet often difficult part of the process. For new IGG practitioners who are just beginning their journey, and established practitioners alike, the process of “breaking the ice” with law enforcement regarding cold cases, and “igniting” interest in IGG, can often seem to flame-out, before it ever begins. While the evolution of IGG as an investigative tool remains at least somewhat acknowledged by a majority of law enforcement investigators around the country, the process of reopening cold case investigations from a law enforcement perspective, is often far less understood by those who practice IGG.

This presentation will explore various challenges associated with reopening cold case investigations through the lens of a law enforcement investigator, and discuss some of the political, logistical and fundamental reasons why law enforcement agencies often appear reluctant or apprehensive to work with IGG practitioners. The presenter will use his prior experience as a law enforcement investigator exposed to IGG in various cold case investigations, along with his work as a current law enforcement liaison for several IGG centered organizations, to discuss and analyze various hurdles faced by new IGG practitioners who are attempting to find work. This presentation is intended to enhance the IGG practitioner’s overall knowledge and understanding of cold case investigations from a law enforcement perspective, in effort to help strengthen their skills at rapport and relationship building among the law enforcement community.

Building Certifications Through Collaboration

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The National Forensic Science Academy (NFSA) was built through collaboration with a focus on enhancing forensic science leadership and practices. A significant milestone in this endeavor was a partnership with the American Society of Crime Laboratory Directors (ASCLD). Together, they developed the Certified Forensic Manager Program (CFMP), a groundbreaking initiative aimed at elevating the standards of forensic leadership and management. The CFMP provides standards for Authorized Providers to develop comprehensive training as well as for forensic science professionals to earn a Certified Forensic Manager Certification (CFM-I, CFM-II, and CFM-III), ensuring they possess the necessary skills and knowledge to lead their laboratories effectively. This collaboration has not only strengthened the capabilities of individual forensic scientists but has also fostered a culture of excellence and continuous improvement within forensic laboratories.

Building on the success of the CFMP, the NFSA has embarked on a new collaboration with the Association of Forensic Quality Assurance Managers (AFQAM). This partnership aims to develop the Certified Forensic Quality Professionals Program (CFQPP) that will develop a national standard of knowledge and professional development for forensic quality assurance professionals, helping to ensure the highest standards of accuracy, professionalism, and ethical conduct. Through the joint development of focused standards that combine learning objectives and learning outcomes, the NFSA and AFQAM are working together to promote standardized practices and foster a community of quality assurance professionals dedicated to advancing forensic science.

The collaboration between the NFSA, ASCLD, and AFQAM exemplifies the power of working together to achieve common goals. By leveraging the expertise and resources of these

organizations, the forensic science community can address complex challenges and drive innovation. This collaborative approach not only enhances the capabilities of forensic laboratories but also strengthens the overall forensic science network, ensuring that it remains resilient and adaptable in the face of evolving demands. As the field continues to evolve, such collaborations will be crucial in ensuring that forensic science remains at the forefront of the justice system, providing reliable and accurate results that uphold the principles of justice and fairness.

Collaborative Efforts to Identify Unidentified Human Remains Through DNA Extraction, Kinship Testing, and Forensic Genetic Genealogy

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The identification of unidentified human remains is a critical challenge in forensic science, requiring innovative approaches and interdisciplinary collaboration. This project highlights a successful working relationship of the West Virginia Forensic Genetic Genealogical Commission. Members of the West Virginia Forensic Genetic Genealogical Commission include the Marshall University Forensic Science Center (MUFSC), West Virginia Office of the Chief Medical Examiner (WVOCME), West Virginia State Police Forensic Laboratory (WVSPFL), West Virginia Fusion Center (WVFC), West Virginia State Police (WVSP), and West Virginia Prosecuting Attorneys Institute. Through coordinated efforts, attempts to resolve 45 cases of unidentified human remains utilized diverse biological samples, including blood cards, long bones, teeth, and skulls, demonstrating the versatility and effectiveness of collaborative methodologies in forensic investigations.

To date, over 20 agencies across the state of West Virginia, as well as 7 agencies across four states and Washington, D.C., have contributed to the collection and analysis of unidentified human remains and available reference samples. After transferring human remains to Marshall University Forensic Science Center, the project began with DNA extraction from complex, often degraded samples. These required careful handling and advanced techniques to recover sufficient genetic material despite varying conditions. The unidentified human remains were discovered in different stages of decomposition in environments such as shallow graves, bodies of water, and burned structures.

After generating DNA profiles, Marshall University Forensic Science Center performed kinship testing using traditional forensic methods when familial reference samples were available, leading to the identification of 26 unidentified human remains. For cases with tentative identities, we await additional reference submissions. When STR profiles were developed but kinship analysis was not possible due to an absence of suspected identity, samples were submitted to the West Virginia State Police for entry into CODIS. If no matches are found, the West Virginia Forensic Genetic Genealogical Commission employs forensic genetic genealogy to reconstruct family trees and identify relatives using publicly accessible databases. Currently, six cases are undergoing this process.

Significant progress has been made in identifying remains and reuniting families with their lost loved ones. This collaboration exemplifies the importance of interdisciplinary partnerships in forensic science. The coordinated use of resources, expertise, and technology across agencies resulted in not only case resolutions but also improvements in protocols and methods that can be applied to future investigations. By combining traditional forensic methods with cutting-edge techniques like genetic genealogy, the team established a comprehensive framework for tackling unidentified human remains cases effectively.

This project marks a significant advancement in the identification of unidentified human remains and sets a precedent for future collaboration in forensic science. Its findings highlight the power of interdisciplinary teamwork in solving complex cases. The successes achieved reinforce the need for ongoing partnerships to enhance forensic methods, improve identification efforts, and bring closure to families affected by unresolved disappearances.

Construction of a Microhaplotype Panel for Complex Mixture Deconvolution using Next-Gen Sequencing

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Microhaplotypes (MHs) are short DNA regions (<300 nucleotides) containing two or more SNPs with multiple allelic combinations. Current sequencing technologies reveal that MHs offer significant advantages over STRs in analyzing complex and imbalanced mixtures. Key benefits include the absence of stutter artifacts and uniform allele size, which makes preferential amplification of smaller alleles a non-issue. Moreover, loci with a high effective number of alleles (Ae) also provide substantial ancestry information (In), much more so than conventional forensic STRs, potentially allowing biogeographical ancestry inference even for minor contributors to a DNA mixture.

Large genome sequencing projects including, but not limited to, 1000 Genomes, Genomes Asia, and gnomAD, have provided databases of whole genome sequence information. These resources have allowed researchers to explore SNP variation across populations using advancements in bioinformatic tools and identify numerous MH loci with an Ae comparable to, or exceeding, forensic STRs. The comprehensive repository of MH loci MicrohapDB, includes over 3000 loci detailing marker locations, Ae, In, and specific allele-defining SNPs. Aiming to develop a sequencing-platform agnostic multiplex MH assay for complex mixtures, 43 MHs were selected for primer design with the AmpliSeq system. Using MicroHapDB, loci were sorted based on their Ae focusing on markers with lengths less than 270 base pairs and an Ae > 5. This narrowed-down pool was further assessed based on the following set of parameters: ranges and standard deviation of Ae values from the different populations, presence and frequency of indels, the occurrence of homopolymers longer than 5 nucleotides, and the BLAST search results for each marker. Initially, approximately 250 markers were identified, some of which had been included in a panel by Bode Technology and in the Kidd 24-locus panel. Markers that demonstrated a high Ae value, but were too long, were evaluated for length reduction and Ae values were re-calculated. Any marker that showed a significant reduction in allelic diversity was further eliminated.

Seventeen individuals from diverse ancestries were chosen from an IRB-approved GW collection. Various mixtures, ranging from two to five contributors with different ratios, were

sequenced on a Gene Studio S5. Sequence alignment was conducted with the Torrent Suite™ Server by TMAP to produce mapped bam files. The bam files were then processed with the JAVA-based application mh.jar, available from Thermo Fisher Scientific, which generates allele calls based on relative coverage. Although primer concentration can be optimized, the preliminary data shows a read coverage ratio of sister alleles, averaged across loci and samples, of 77%, with random match probabilities less than one in 10^50 for single-source samples. The sensitivity to detecting minor contributors is equal or greater to that of STRs, detecting 58% and 43% of unique minor contributor alleles in a 1:40 and 1:60 mixture, respectively. The multiplex is also being tested on the MiSeq sequencing platform and next steps include (1) generating allele frequencies both empirically by testing ~250 GW samples from individuals across the major US populations and in-silico by utilizing data from large sequencing project such as 1000 Genomes and gnomAD, (2) optimizing inter-locus balance by adjusting primer concentrations, and (3) adapting probabilistic genotyping tools to incorporate MH data for mixture deconvolution and analysis.

Crypto Wallet Detection and Analysis Tool Using Seed Phrases

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A crypto wallet is a software tool that allows users to manage their cryptocurrencies from a secure and easily accessible platform; seed mnemonics often back up these wallets. Seed mnemonics are a list of words that allow users to gain access to the wallet they belong to. The nature of cryptocurrencies, which attract malicious activities, has made it necessary for forensics investigators to extend their reach to crypto wallets forensics, as crypto wallets may contain vital information for resolving an investigation. Our program automates the process in which crypto wallet addresses are generated, and information is extracted from the blockchain. We make use of a crypto seed mnemonics and reverse engineering processes to recreate the wallet addresses, while using APIs to query our desired information from the blockchain.

The first step towards regenerating addresses from mnemonics is to understand the structure of crypto seeds. The most common seed generation methods are BIP39, and SLIP0039; these methods are distinct from one another as they undergo different processes to generate their seeds. Furthermore, each of these methods have different ways in which they generate their mnemonics, BIP39 has a 2048-word long wordlist and selects words based on random entropy and 11-bit segmentation of pairs, whereas SLIP0039 has a 1024-word long wordlist and has the mnemonics split by Shamir’s Secret Sharing, meaning that a threshold number of shares is needed to recreate a wallet. Having these differences in mind, we are able to identify to which generation protocol a seed belongs to, thus allowing us to dictate which processes we need to undertake to generate the seed appropriately. Lastly, upon generating the correct seed from the mnemonics, we make use of derivation paths, a structured format that dictates a wallet’s behavior, to create addresses for specific accounts and cryptocurrencies.

Developing novel mitochondria DNA (mtDNA) digital polymerase chain reaction (dPCR) assay for speciation of fecal contamination on agricultural produce.

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The consumption of foods, especially fruits and vegetables contaminated with feces, can lead to about 48 million cases of foodborne illness, 128,000 hospitalizations, and 3,000 deaths annually in the United States, as estimated by the Center for Disease Control and Prevention (CDC). Fruits and vegetables carry a significant microbial contamination risk due to various environmental factors affecting their growth, harvest, and distribution from farm to fork. These issues also result in a great deal of economic hardship and fear associated with the need to track and recall the contaminated produce.

Conventional methods for pathogen detection on food often require labor-intensive and expensive methods involving the use of cultures and other biochemical procedures. Recent techniques utilize real-time or quantitative polymerase chain reaction (PCR)-based primers and probes to detect specific bacteria, however, the complex matrices of these samples can sometimes limit accuracy, specificity, and sensitivity. A potential alternative is a more rapid, precise, and sensitive nanoplate digital PCR method. This technique partitions the samples into thousands of individual wells, (8.5K or 26K) to improve specificity and reduce problems with PCR inhibition. The results obtained are quantified with Poisson distribution based on the presence or absence of the target gene in each discrete well.

The purpose of this study is to develop a digital PCR method to detect fecal contamination on agricultural produce (i.e. strawberries) and to compare results obtained with real-time PCR-based methods. Fecal samples from cattle, rodents, poultry, and other animals was collected, and bacterial DNA extraction and quantification were performed with modified primers and probes. Mitochondria DNA (mtDNA) primers and probes was also developed to ascertain the origin of fecal contamination as well as detect individual vertebrate species. Multiplex assays were developed, optimized, validated, and the resultant procedures was tested on inoculated and unwashed fruit. The results showed that dPCR was capable of femtogram levels of bacteria detection in a sample, and the mtDNA probes were species-specific in determining and tracking the origin of foodborne illness.

Digital Forensics: Smarter Solutions For Mass Disaster Victim Management

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The identification of deceased individuals involved in mass disasters is a crucial process to ensure the proper handover of remains to their next of kin for burial arrangements according to their respective religions. To date, the process of recording information related to the

identification of bodies still relies on outdated manual methods. This antiquated approach hampers the quick and efficient dissemination of information between healthcare workers and rescue personnel, such as police officers, across the country. The reliance on handwritten forms and physical documentation increases the risk of data loss, misinterpretation, and unauthorized access. Additionally, the storage of forms in record units is less secure compared to digital storage methods.

Method: The Forensic Data Management System for the identification of bodies in mass disasters is proposed to address these issues, focusing on the digital input and storage of data. The development of this system uses the spiral methodology, which consists of four phases: planning, risk analysis, development, and evaluation. This methodology is crucial to ensure that the project development process proceeds as expected.

Discussion: Security features are also embedded in this system, such as identity verification for involved personnel, where only registered staff with credentials stored in the database are allowed to access the system's information. This ensures data integrity, confidentiality, and controlled information dissemination.

Conclusion: This system is expected to assist rescue personnel, medical officers, forensic experts, and police officers in securely, quickly, and efficiently managing identification reports, ultimately improving response times and accuracy in mass disaster scenarios.

Environmentally friendly paints yield significantly different IR spectra over time

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Forensic comparison of paint chips is an essential type of trace evidence analysis. Standard paint chip analysis for chemical composition is performed rapidly using Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FT-IR). This process allows an examiner to determine the chemical “fingerprint” of the paint and identify the major components used to manufacture the paint, including the binders. Paint chips can also be compared to one another based on these spectra. While this methodology is regularly applied by the forensic science community for standard paint coatings as well as degraded paint samples, the advent of environmentally friendly paints has the potential to pose a new challenge to examiner interpretation. These environmentally friendly paints are advertised as being able to absorb volatile organic compounds from the air in the room in which they are painted. If these volatile organic compounds are being absorbed, this could potentially impact the infrared spectra produced in the analysis. This study examined two brands of these paints: SuperPaint® Interior Acrylic with Air Purifying Technology, by Sherwin Williams®, which claims it “helps reduce volatile organic compounds (VOCs) from potential sources like carpet, cabinets, and fabrics” and four different paint types by ECOS Paint®, which claims their paints include “a molecular sieve which is designed to both stop harmful volatile organic compounds from being released into the air and to trap them as they float though a room”. These paints were chosen due to their statement of absorbing and trapping volatile organic compounds. If these paints are absorbing volatile organic compounds, the expectation is that we would observe changes to the infrared

spectra produced over time. Each paint was applied in two coats onto wooden craft sticks generating five replicate sticks. ATR-FT-IR spectroscopy was performed on all sticks in replicate starting at week zero to produce an initial spectrum, through 69 weeks. Spectra were normalized and eight spectral peaks were chosen to obtain absorbances. Absorbances analyzed with a single-factor ANOVA showed there was a significant difference in peak intensities over time ($p < 0.05$). Additionally, plotting peak intensities over time shows that these changes are not predictable depending on the brand of paint. These findings demonstrate the importance of being aware of societal changes impacting paint formulations. Environmentally friendly paints, such as these, have been increasing in the marketplace and forensic chemists need to be aware of how they can impact their analysis.

Exploring New Psychoactive Substances: A Comparative Evaluation of Targeted vs. Nontargeted Detection Approaches in Human Matrices

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This study aims to assess and compare the effectiveness of targeted and nontargeted mass spectrometry (MS) methods in detecting 40 different new psychoactive substances (NPS) in human biological samples. The rapid rise of NPS has created significant challenges for their detection and identification, given their diverse chemical structures and quick introduction into the market. Targeted analysis, often performed using low-resolution mass spectrometry (LRMS), focuses on predefined substances, providing high specificity. On the other hand, nontargeted analysis, employing high-resolution mass spectrometry (HRMS), allows for a broader screening, enabling the identification of both known and unknown substances.

In this study, drug-free human urine, whole blood, and oral fluid samples were spiked with a mixture of 40 NPS, including various isomers and metabolites. These samples were analyzed using LC-MS systems coupled with both LRMS and HRMS platforms. The targeted analysis employed LC-QqQ-MS, while the nontargeted analysis was carried out with LC-QTOF-MS and LC-Q-Orbitrap-MS. Two acquisition modes, Auto MS/MS and All-Ions, were compared for nontargeted screening, with Auto MS/MS showing higher sensitivity and selectivity for known substances, while All-Ions provided more comprehensive detection, including unknown compounds and better resilience to matrix effects.

The results showed that targeted analysis with LC-QqQ-MS generally outperformed HRMS methods in terms of sensitivity, selectivity, and performance across all specimen types, with urine samples yielding the best results. However, nontargeted analysis proved essential for discovering new and emerging substances. This study highlights the complementary strengths of both approaches and proposes a framework for integrating them in forensic and clinical settings to improve NPS detection, enabling more effective public health and forensic responses to these evolving threats.

Evolution of Information Models from Forensic Intelligence to Artificial Intelligence

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Forensic science has undergone a profound evolution from early foundations in Egypt, Greece, India and China thousands of years ago to the rapid developments in the 19th-century including manual identification systems, followed by the emergence of DNA and Digital forensics in the 20th century until the current day integration of cutting-edge artificial intelligence (AI) technologies. This talk explores that trajectory, including Alphonse Bertillon's anthropometric system as an early data-driven method of criminal identification and tracing the development through developments of the fingerprint databases (IAFIS), DNA profile databases (CODIS), and ballistics networks (NIBIN). Each step added to the systemizing of forensic data and, in turn, paving a pathway for current AI-driven forensic approaches. The emergence of AI and machine learning (ML) in the forensic domain is nascent, but is becoming significantly relevant to criminal justice and evidence analysis. In lockstep with these applications, we discuss critical challenges and risks, like biases in training data, the "black box" problem of explainability, as well as legal hurdles in meeting evidentiary standards. Policy and ethical considerations are addressed, noting recent government initiatives that aim to guide the responsible development of AI in forensic science and related domains. By following the historical themes through to the contemporary innovations, and examining both the promise and perils of AI in forensic science, this talk sets the stage for informed discussions on the future integration of AI into forensic science practice.

Finding the trace: past, present, and future research at the Wildlife Forensic Academy

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The Wildlife Forensic Academy (WFA) opened its doors in 2022 as the world's first dedicated training facility for wildlife forensics. Our primary remit is upskilling and empowering rangers and first responders in crime scene-to-court techniques and processes for wildlife crime. But wildlife crime scenes are dynamic and vary greatly by country, territory, and local environment - each presenting their own unique combination of challenges especially when set within the socioeconomic and judicial contexts of their occurrence. Such complexity and specificity demands continuous research to optimize existing forensic practices and, where necessary, develop new ones.

The research at the WFA has grown since the facility opened its doors. The primary vehicle for research at the WFA has been through visiting internship projects, primarily undergraduate

and postgraduate university students. These have spanned from animal welfare, to optimizing application of well-known forensic science techniques to wildlife crime settings such as fingermark analysis, to novel applications of ancillary technologies such as isotope analyses for provenancing of wildlife and products thereof.

Through our presentation we will highlight the diversity of the research supported at the WFA, past and current, and share our plans for what we believe are some exciting future research developments in the wildlife crime space.

Forensic Crime Scene analysis of Glass Pane Penetration patterns: A case report

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Glass plays a significant role in the everyday life. Broken glass is often encountered in the crime scenes of shooting or burglary cases. The study of glass fracture also known as fractography provides important evidence for the investigation of any penetration of a glass surface, whether by a projectile or blunt tool. The case report serves as an example to understand the crime scene investigation for forensic professionals and law enforcement personnel, especially in determining the fracture pattern, the cause of the fracture, the type of tool used, if projectile used, the range of firing, etc. The case report involves an alleged complaint of bullet firing in the area of the south end of Kolkata. The examination of the crime scene revealed critical findings like no evidence of penetration of any high-velocity projectile, and one pink-colored curtain hanging in front of the window towards the room, where no mark of any hole could be observed on the curtain. To unravel this mystery, investigators employed laser rays to trace possible paths of penetration, coupled with thorough gunshot residue analysis to gain a comprehensive understanding of the events. On requisition by the deputy commissioner of police, a forensic time under the leadership of the author (T. K. Mukherjee) visited and examined the scene of the crime and revealed the actual truth. These findings revealed the true nature of the incident, emphasizing the essential role forensic science plays in the pursuit of justice and the accuracy of criminal investigations.

Importance of Medico-Legal Death Investigation

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In the forensic science community, medicolegal-death-investigation has become progressively vital in crime scene analysis, working alongside medical examiners and coroners. As seen in many state districts, medical examiners typically work closely with law enforcement but are not always called to a crime scene due to resource constraints. Medicolegal death investigators (MDIs) step in to examine crime scenes, hypothesize the potential manners of death, collect

medical information and evidence, and determine if an autopsy is necessary for the local medical examiner.(1)

MDIs are trained forensic professionals with medical backgrounds who have the authority to categorize the manner of death. With the collected information, they have the decedent transported to the medical examiner's office for further forensic analysis. The medical examiner conducts needed medical tests, an autopsy report, and endorses the death certificate.(2)

Medical examiners and death investigators roles play a part to serve justice and to combat global health security by reporting the deaths in Medicolegal-death-investigation systems. Reporting the deaths can inform professionals how to prevent deaths by studying the disease or injury. About 20% out of around 450,000 deaths a year get reported to these databases based on the lack of trained professionals in the field from each district.(3) Regardless of the development of the medicolegal-death-investigation database systems, there are a lack of support needed to increase the amount of professionals in the field who are trained to report data. It is estimated that in the United States, there are less than 700 medical examiners and less than 200 districts using Death Investigators full-time.(3)

The National Institute of Justice states that around double the number of districts and certified medical examiners are needed to satisfy the staffing requirements in the forensic medicine field.(4) It is possible to increase the number of forensic medicine post-graduates needed to address staffing shortfalls by improving the resources available and investing in training and programs are crucial points needed to strengthen the field and encourage others to pursue careers in forensic medicine.(5)

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Improving IMS-based non-contact detection of dangerous substances

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Drug abuse continues to pose significant challenges to public health and law enforcement, with substances like cocaine, heroin, MDMA, and methamphetamine presenting substantial risks due to their chemical properties and patterns of misuse. Cocaine and heroin are leading

contributors to overdose fatalities; cocaine, a stimulant, can cause fatal cardiac events and strokes, while heroin, a depressant, often leads to deadly respiratory failure, especially when laced with fentanyl. MDMA (ecstasy) presents dangers beyond its psychoactive effects, including dehydration, hyperthermia, and potential cardiovascular complications. Methamphetamine, a potent central nervous system stimulant, is associated with severe neurotoxicity, cardiovascular damage, and a high risk of addiction. In addition to these substances, Triacetone Triperoxide (TATP), a volatile, homemade explosive, introduces further hazards in clandestine laboratories, as it is frequently mistaken for illicit drugs due to its white powder form.

Detecting these substances in the field is challenging due to their handling risks. Recent advancements by Fulton et al.[1] have demonstrated non-contact fentanyl detection using a field portable Ion Mobility Spectrometry (IMS), but the technique was challenged by low vapor availability from diluted samples. This study addresses this limitation by developing a novel pre-concentrator: a Silicon Nanowire (SiNW) array[2], coated with acrylate-based polymers that can selectively collect and concentrate target vapors, to enhance vapor pre-concentration prior to detection for improved IMS detection of dangerous substances.

The optimal polymer coating for the SiNW array is selected by screening five acrylate-based polymers, pre-determined for their vapor pre-concentration capabilities. The acrylate-based polymers are screened using a Quartz Crystal Microbalance (QCM) for target vapor surrogates of these dangerous substances, methyl benzoate (cocaine), acetic acid (heroin), TATP, piperonal (MDMA), and benzaldehyde (methamphetamine). In this process, analyte vapors are swept over polymer-coated sensors using argon as a carrier gas, and the resulting frequency changes are measured. Sauerbrey mass deposition of analytes is calculated using the Sauerbrey equation to determine the most effective polymer for each target vapor.

Preliminary results indicate that DMAEA is the optimal polymer for methyl benzoate and acetic acid, while the best coatings for other analytes are under investigation. The next step of the research involves coating a SiNW array mounted on a microchip using the chosen optimal coatings, and integrating it into a field-portable IMS. This approach addresses the current limitations of IMS by enhancing detection sensitivity and expanding its capability to identify a broader range of dangerous substances. This innovation aims to improve first responders' safety while enabling more effective forensic and law enforcement applications.

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Interrogating Identity of Donated Remains using Macro and Molecular Approaches in Forensic Science

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Quantitative polymerase chain reaction duplex (qPCR-multiplex) is a technique able to target and co-amplify two genetic markers in a single reaction to provide sex determination for DNA samples extracted from human skeletal remains. Further information for unidentified remains can be obtained by determination of ancestry through single nucleotide polymorphisms (SNPs) targeting the D-loop region of mitochondrial DNA (mtDNA). A qPCR-multiplex was utilized in this study to develop methods for rapid molecular sex determination using sex specific genes; testis-specific Y-encoded protein 1 (TSPY) and steroid sulfatase (STS), as a means to increase the sensitivity of current molecular sexing methods. Additionally, traditional PCR was used on the extracted samples to aid in the determination of ancestry. Sequencing then identifies SNPs that match established haplogroups present in the mtDNA. Modern DNA from the Madonna University exclusionary database (ED) provide positive controls to optimize reactions and test the accuracy of target DNA fragments in both traditional PCR, and multiplex methods. Bone powder from the femora of anthropologically sexed teaching skeletons (six females, one male) were obtained from Clay Adams Company to determine whether the multiplex reaction can verify sex of degraded DNA through molecular methods. The age of these bones is unknown, but preliminary research suggests that the femora samples likely originate from South Asia, prior to India's 1984 ban on the exportation of human osteology. Degraded DNA in these samples were defined in the context of the 40-year-old ban, as the DNA may have deteriorated over time since the exportation restrictions were enacted. The presence of the X or Y chromosomes was visualized for sex determination using a UV transilluminator after staining the gel. The PCR displays as one amplicon for female DNA and two amplicons for male DNA. Similarly, real time PCR presents one peak for female DNA and two peaks for male DNA on a thermal denaturation curve. This process was validated from modern DNA using the Madonna databases showing sex primers of the multiplex reaction were successful. Preliminary results of degraded sample extractions have been successful, providing sensitive molecular methods that contribute to rapid analysis of unidentified skeletal remains.

Multidimensional forensic procedure to identify Methamphetamine adulterated with Menthol

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Since 2020, there has been a significant increase in the frequency and scale of methamphetamine and heroin seizures within Sri Lankan maritime limits. In 2023, the mid-sea seizure of a consignment with 84 kilograms of a white crystalline substance suspected as

methamphetamine and 99 kilograms of brown coloured powder suspected as heroin was submitted to the Government Analyst's Department of Sri Lanka for further investigation.

Qualitative analysis of the brown colored powder confirmed the presence of heroin along with caffeine, a commonly used adulterant. Qualitative analysis of the white crystalline substance from the same seizure identified the presence of methamphetamine and menthol. Mixing the menthol crystals with methamphetamine crystals seems to be a strategic concealment method designed to mimic the drug's appearance and potentially evade detection. This was the first time menthol crystals were identified from a marine seizure of methamphetamine in Sri Lanka. Unlike street-level drug samples, past maritime seizures typically contained high-purity narcotics with a low level of adulteration.

The crystalline similarity between menthol and methamphetamine posed a risk of misidentification during visual inspection.

Marquis test which is a presumptive color test commonly used in the preliminary screening phase of illicit drugs, methamphetamine typically yields an orange coloration upon the marquis reagent. The test on menthol produced a yellow shade, creating a higher possibility of misidentification as cathinones or New Psychoactive Substances (NPS).

When menthol was tested on the Gas Chromatography-Flame Ionization Detection (GC-FID) method routinely used in the laboratory to quantify methamphetamine, menthol exhibited a retention time closely eluting to that of methamphetamine. This close elution pattern increased the risk of inaccurate quantification, further intensifying the analytical complexity.

The quantification results of the test samples of this consignment observed 1.2% and 65.5% of heroin and methamphetamine, respectively, relatively lower than other marine seizure materials.

This case highlights the importance of implementing a multidimensional forensic approach when dealing with unknown substances. A combination of preliminary tests, including several color tests, thin-layer chromatography (TLC), and advanced techniques such as Raman spectroscopy, Fourier-transform infrared spectroscopy (FTIR), and Gas Chromatography-Mass Spectrometry (GC-MS), are essential for accurate identification.

Thus, an evidence-based multidimensional forensic approach can ensure both scientific accuracy and legal integrity in narcotics investigations by effectively differentiating controlled substances from potential adulterants or masking agents.

Optimizing Extraction Parameters Using Design of Experiments for the Detection of Single Dose Drug Exposure in Forensic Hair Analysis

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Hair is a complex biological matrix that serves as a valuable resource for detecting substance exposure beyond the typical detection windows of conventional biological samples. On average, drugs incorporate into hair within approximately 10 days and can be identified for weeks to months post-exposure. This extended detection period is particularly beneficial in cases of drug-facilitated sexual assault (DFSA) and drug-facilitated crime (DFC), where only a single dose of a substance may have been administered. However, identifying single-dose exposures poses significant challenges due to the necessity for extremely low limits of detection (LOD) and

quantitation (LOQ). Currently, there is limited research on detecting single-dose drug exposures in hair, and no universally standardized forensic hair analysis method exists.

Given the multiple variables influencing drug detection in hair, an optimized forensic hair analysis method is essential. The primary aim of this study is to develop such a method. This research employs Design of Experiments (DoE), a statistical methodology that evaluates relationships between independent variables and their effects on a dependent variable. DoE was applied in this study to optimize hair extraction conditions by systematically comparing different variables. Authentic Hair Reference Material (HRM) with known drug concentrations was used to assess extraction efficiency under various conditions.

A liquid chromatography-tandem mass spectrometry (LC-QqQ-MS) method was developed to detect 47 drugs and metabolites commonly associated with DFC. The system consists of an Agilent 1290 UHPLC coupled to a 6470 LC-QqQ-MS/MS, operating in both positive and negative electrospray ionization modes. Separation was achieved using a Zorbax Eclipse Plus C18 column (3.0 × 100 mm, 1.8 µm) with a guard column. The gradient elution began with 5% mobile phase B for 5 minutes, increased to 95% by 8 minutes, and was held for 2 minutes at a flow rate of 0.3 mL/min. The aqueous phase (A) comprised 5 mM ammonium formate with 0.1% formic acid in water, while the organic phase (B) contained 0.1% formic acid in methanol.

The hair sample preparation involved solvent extraction following an optimized decontamination protocol, which included a 30-minute water wash followed by three 30-minute washes with dichloromethane. After drying overnight, hair samples were weighed and placed into a steel milling jar for homogenization using a Mini-Bead Beater 24 ball mill (Biospec, Bartlesville, OK, USA). The samples were pulverized in 10-second intervals for a total of 30 seconds at 3200 rpm, resulting in finely ground hair. The DoE protocol was a 23 full factorial assessment that evaluated three factors A, B and C. This included different sample sizes A- (5 mg or 20 mg), extraction times B- (2 h or 6 h), and the effect of an ultrasonic bath C- (with or without) on the method. Ultrasonication paired with the solvent swelling has been shown to improve recovery of certain drugs from hair.

The results of the DoE show the optimal sample amount of hair for factor A was 5 mg compared to the 20 mg, with the p-values showing statistical significance. For Factors B and C, a 6-h extraction time, and the addition of ultrasonication yielded a higher percent recovery overall, however the p-values did not support statistical significance. The highest preforming overall method consists of 5 mg of hair, 6-h extraction time, and with ultrasonication, which yielded the highest percent recovery. This research presents an optimized working method for quantitative analysis of drugs in hair. Future work will include a secondary DoE evaluation of different extraction techniques and a validation of the final optimized method using the ANSI/ASB Standard 036 guidelines. The optimized method will also be evaluated for the detection of single doses of drugs in hair using authentic single dose samples.

Presentation on the Final Report on Complaint No. 23.67;
Evaluation of Biological/DNA Results Given Activity Level Propositions

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Questions intended to elicit inference ‘beyond the source’ of forensic DNA are increasing in court. Given DNA technology has advanced to the point where the systems are so sensitive,

analysts need to realistically consider whether the trace detected is even related to the crime being investigated. In response to the increase in “how” questions, evaluation of genetic findings given activity level propositions has been suggested as a path forward in addressing this trend in forensic DNA. Such was the case in State of Texas v. Kaitlin Armstrong.

The NIST Expert Working Group on Human Factors in Forensic DNA Interpretation was first to formally recommended the US government to fund foundational research that would underpin evaluative opinions in the United States. The Texas Commission on Forensic Science issued a report related to TX v. Armstrong that identified what issues the US DNA community would have to address before these opinions should be offered in court in the state of Texas. The NIST Foundation Review of DNA Mixture Interpretation has now cited both documents, echoing recommendations on what research and systems need to be established before evaluative opinions should be offered in US courts. Even though there have been hundreds of studies performed with the intent to inform evaluations of genetic findings given proposed activities, further research is necessary, there is a need to educate and standardize the researchers performing these studies to ensure the data being generated is fit for purpose.

This presentation will describe the series of events in Texas v. Armstrong, problems identified and way in which the case should be used as a roadmap in the future for evaluating new methods and technologies prior to widespread implementation in US laboratories.

Qualitatively Identifying Counterfeit Drugs via Gas Chromatography-Mass Spectrometry

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Counterfeit drugs pose an increasing threat to American citizens due to industry monopolization concerns in the United States, such as the lack of accessibility and increasing costs. As a result, over the counter (OTC) drugs from foreign stores and online vendors are now being increasingly obtained by Americans. Thus, counterfeit drugs are available through mass production and are now widely distributed, with millions of counterfeit drugs seized every year with the numbers still on the rise. Due to lack of regulation, counterfeit drugs may omit the attested active ingredients while others contain falsified active ingredients or dangerous additives. When active ingredients are not present, the drugs will produce undesired biological effects or no effects at all. These effects can be harmless, minimal, or severe; potentially resulting in harm to the user or even death. Various tablets composed of herbal ingredients or medicinal compounds were purchased from seven online vendors for use in this study. Test samples were labelled prior to being dissolved and diluted in dichloromethane (DCM) or ethyl acetate (EtOAc) for analysis via Gas Chromatography-Mass Spectrometry (GC-MS). To probe for active ingredients, GC-MS spectra were analyzed to determine peak masses, intensities and viability for identification. This allowed for the verification of the presence or absence of the main active compounds that correspond to the labelled ingredient with the highest concentration. The Selective Ion Recording (SIR) mode of the GC-MS allowed for the specific masses of the active ingredients to be assessed. After the target masses were identified and located, a confidence level was applied to the sample peaks and were verified as counterfeit or non-counterfeit. Lastly, data analysis was performed to assess the correlation between drug type and producer to provide a determination on whether the test samples were illegitimate and/or potentially dangerous. This project aimed to assess the

risk of certain counterfeit drugs, including common wellness supplements and pain relievers that can be obtained through online stores, over the counter, or on retailer shelves. Final determinations of this study will be used to raise public awareness of counterfeit drugs that should be avoided.

Self-Healing Gunshot Damages in Vehicles: Challenges in Forensic Crime Scene Reporting

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Introduction: Crime scene reconstruction is a crucial systematic approach used by forensic experts to interpret the sequence of events that took place at a crime scene. In firearm-related crimes, determining the trajectory of a bullet plays a significant role in understanding the nature of a shooting incident. Forensic ballistics experts frequently examine vehicles to Identify the gunshot damages. At a crime scene, in the presence of a ballistic impact, identification of the entrance and exit points of bullets is one of the first tasks. This is done based on the characteristics of the damage perimeter, which are decided not only by the projectile, but also by the material of the target. In some cases, the usual signs of ballistic damages may not be available, making it more challenging to identify a damage as a gunshot impact. This article discusses two such cases where gunshot damage was not immediately visible during the preliminary examination of vehicles in firearm-related crimes.

Case 1 – A Car: This case involves an unreported misfire by a security official. A bullet was discovered inside the fuel tank of a car. Upon external examination, no visible entry gunshot damages were detected. However, a detailed inspection done jointly with a mechanical expert revealed that the bullet had entered the vehicle through the plastic rear bumper. The only visible damage on the bumper was a 0.8 mm diameter mark, which could easily be misinterpreted as a minor scratch. Damages on multiple vehicle components of the bullet trajectory were identified when further examination was carried out though a through and through damage on the bumper was not available.

Case 2 – A Pickup Truck (with a covered rear cargo bed): A passenger traveling in the covered rear cargo bed of a pickup truck was fatally shot. Examination of the damages on the rear parts of the vehicle indicated that the firing had been taken from behind, using a rifle. Two exit holes on the windscreen, confirmed the bullet's trajectory. However, no apparent entry holes, for the shots causing the fatal injury were externally visible. Upon thorough inspection, five 0.1 mm marks were observed on the rear doors of the cargo bed cover, which was made of plywood and covered with rexin (artificial leather). Upon removing the rexin, distinct entry damages were detected on the plywood door.

Conclusion: In both cases, preliminary external examinations failed to identify the bullet entry points due to the nature of the impacted materials. Car bumpers are typically made from a

combination of plastics, including polypropylene, polyurethane, and polyvinyl chloride (PVC). Rexin is a coated fabric, often PVC-coated. These materials can self-seal upon an impact of a bullet, due to the heat generated, making difficult to detect the gunshot entry damages. Given these challenges, forensic ballistics experts must pay careful consideration on exit damages and sequential damages on other vehicle components in vehicle examinations. Support from mechanical experts in disassembling vehicle parts to uncover concealed ballistic evidence should also considered.

Forensic crime scene investigators must be aware of these challenges to ensure accurate crime scene reporting to prevent potential misinterpretations of evidence.

That's Some Pig: Protocol Optimization for the Analysis of DNA in Unpulverized Cremains

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This study investigates the extraction of mitochondrial DNA (mtDNA) from unpulverized cremated remains, using Sus scrofa domesticus bones as a proxy for human remains. The research aims to optimize a protocol that can be used in forensic investigations to identify cremated or unidentified decedents. This includes those whose remains may have been commingled or switched in cases such as arson, mass disasters, or military conflicts.

Porcine bone was chosen due to its similarity in size, structure, and genetic makeup to human bones. A pig's cranium and two hocks were selected for cremation at 1600°C for 105 minutes. After cremation, samples were classified into compact and spongy bone, with only compact bone selected for DNA extraction. The PrepFiler™ BTA Forensic DNA Extraction Kit was used for the DNA extraction, which was then amplified through polymerase chain reaction (PCR) and sequenced using the BigDye™ Terminator v1.1 cycle sequencing kit on a SeqStudio Genetic Analyzer.

The optimized protocol demonstrated success in isolating and sequencing mtDNA from unpulverized cremated remains, showing its potential for identification in forensic contexts. The protocol will now be applied to human cremains donated to Madonna University to test its effectiveness in confirming identity. This will involve comparing the extracted mtDNA to a familial reference sample to identify a common maternal lineage, further validating the method for forensic use in human cremated remains identification.

The success of this method could significantly enhance the ability to identify individuals in forensic investigations where traditional identification methods are not viable, offering a valuable tool for law enforcement, military, and disaster response teams.

The impact of GC-MS integrator selection – an expanded uncertainty assessment of the ChemStation and RTE integrators

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Gas chromatography-mass spectrometry is one of the most widely used analytical techniques in forensic laboratories due to the ability to chromatographically separate components of a mixture before mass spectrometry detection for either qualitative or quantitative analyses. As with all analytical techniques, there is uncertainty associated with gas chromatography-mass spectrometry measurements. Unfortunately, the assessment and communication of measurement uncertainty can be challenging for forensic laboratories. Although many organizations publish their acceptance criteria for retention time and relative ion abundance measurements, there is substantial variability between organizations and little discussion about acceptance criteria for chromatographic peak area. As part of a larger longitudinal study assessing the uncertainty of gas chromatography-mass spectrometry chromatographic peak area for 16 commonly encountered seized drugs, this research focuses on the impact of the ChemStation and RTE integrators on the peak area and retention time measurements using an expanded uncertainty assessment.

An Agilent 8890-5977B gas chromatograph-mass spectrometer was used to analyze a 16-component mixture of common seized drugs at low and high concentrations, relative to analyte potency. The mixtures were analyzed twice a week for a total of six weeks, with five replicates collected each day. The resulting data was integrated using both the ChemStation and RTE integrators available through Agilent ChemStation version F.01.03.2357. Parameters for both integrators were optimized before data collection. Retention time and peak area uncertainty were measured by assessing the expanded uncertainty (i.e., 2*%RSD) across replicate measurements and calculating a combined expanded uncertainty (i.e., Spooled value) for the within-day, within-week, and within-month measurements.

The largest difference between the ChemStation and RTE integrators is that the ChemStation integrator enables time-based programming, whereas the RTE integrator is based on peak area thresholds. Even though the ChemStation integrator contained more complex integration parameters than the RTE integrator, only the peak area measurements were significantly impacted by the choice of integrator. Independent sample t-tests revealed that there was a statistically significant difference ($\alpha=0.05$) between the peak areas, but no statistical difference in the retention time measurements. Interestingly, the peak areas were an order of magnitude smaller for the RTE integrator when compared to the ChemStation integrator, which is due to the way each proprietary integrator calculates peak area. However, when using an internal standard, relative peak area measurements were not found to be significantly different ($\alpha=0.05$). Importantly, although there were differences in peak areas, the expanded uncertainties were typically similar and on the same order of magnitude for both integrators. Ultimately, the choice of integrator does impact absolute peak area measurements, but not relative peak area or retention time measurements. Therefore, as long as one integrator is

consistently used throughout a study, the choice of integrator will not impact quantitation. Nonetheless, each forensic laboratory needs to choose the integrator best suited for their applications.

The Importance of Accreditation in Forensic Science Education for Moroccan Medicolegal Departments

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In Morocco, where forensic science, medicine plays a pivotal role in criminal justice and public safety, implementing accreditation is essential to address educational gaps, align with national development goals, and meet international standards. This presentation examines the importance of accreditation in forensic science education, emphasizing its potential to standardize curricula, improve professional competencies, and ensure ethical and transparent practices.

The benefits of accreditation are multifaceted. For residents, it enhances employability, professional recognition, and access to international opportunities. For institutions, accreditation fosters national and global recognition, attracts funding, and encourages continuous improvement. For the legal system, it ensures reliable forensic evidence, reduces errors, and builds public trust in the judicial process.

Despite these advantages, challenges such as resource constraints, resistance to change, and balancing local and global standards must be addressed. This presentation proposes a roadmap to achieve accreditation, including the development of national standards tailored to Morocco's context, collaboration with international accreditation bodies, capacity building through faculty training and infrastructure investment, and adopting an interdisciplinary approach involving legal, medical, and scientific professionals.

Moreover, accreditation promotes a culture of accountability, innovation, and continuous development, ensuring that forensic professionals are equipped with the skills, ethical standards required to meet evolving societal and legal challenges. As a result, it creates a ripple effect, improving public trust, enhancing judicial efficiency, and fostering social stability. By embracing this transformative pathway, Morocco can effectively bridge the gap between local needs and global standards, securing a brighter, more just future for its citizens and its legal system.

Unmasking the Hidden Dangers: Forensic Analysis of Polysubstance Abuse and Heroin-Cocaine Mixtures in Drug Trade

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Polysubstance abuse, the practice of consuming multiple drugs simultaneously, is a growing concern in modern drug markets. Users and dealers often mix narcotics and psychotropic

substances to enhance or modify their effects. One of the most alarming combinations involves heroin, a depressant, mixed with stimulants like cocaine or methamphetamine. This pairing can mask the sedative effects of heroin, leading to higher doses and an increased risk of overdose. Additionally, such mixtures place extreme strain on the cardiovascular system, heightening the risk of heart attacks, strokes, and fatal respiratory failure.

In May 2024, the Police Narcotic Bureau of Sri Lanka conducted a targeted raid in the Colombo district, resulting a seizure of seven distinct packages containing suspected narcotics, including four packages of a white powder presumed to be cocaine, one package of a solid substance suspected to be 3,4-methylenedioxymethamphetamine, one package of plant material suspected to be cannabis (Kush), and a brown-colored semi solid substance suspected to be hashish. The seized materials were submitted to the Narcotic Laboratory of the Government Analyst's Department for comprehensive forensic analysis.

Preliminary screening was conducted using colorimetric tests, including the Marquis test for opiates and amphetamines, the Scott test for cocaine, and Simon's test for secondary amines. Confirmatory analysis was performed using Thin Layer Chromatography, Fourier Transform Infrared Spectroscopy, Raman Spectroscopy, and Gas Chromatography-Mass Spectrometry to establish the identity of the substances present in each package. Additionally, Gas Chromatography-Flame Ionization Detection (GC-FID) was utilized for the quantification of heroin and cocaine.

Based on the results of comprehensive identification tests, the package containing capsule shaped white powder was confirmed to contain cocaine. The remaining three packages of white powder were found to contain both heroin and cocaine. Additionally, the analysis identified cannabis in the plant material, methylenedioxymethamphetamine in the solid substance, and hashish in the brown-colored semi solid substance.

The quantification analysis determined that the average purity of cocaine in the capsule shaped white powder was approximately 65%. Similarly, the other three packages with white powder exhibited an average purity of heroin 60% and cocaine was present only at trace levels. These results indicate potential adulteration or dilution of the seized substances, reflecting common practices in illicit drug trafficking.

Mostly, white powders submitted for analysis to the Government Analyst's Department, contain substances such as cocaine, ketamine, cathine, methcathinones, or pharmaceutical drugs like tramadol and pregabalin. Due to this established pattern, forensic analysts might not initially suspect the presence of heroin in white powders, increasing the risk of false-negative results during preliminary testing.

This case underscores the importance of implementing a structured analytical scheme that includes both presumptive tests and advanced instrumental techniques. A comprehensive analytical approach is crucial for ensuring the accurate identification of controlled substances, thereby supporting informed legal decisions and maintaining the integrity of forensic investigations.

Unmasking the master manipulators: Investigating and prosecuting intimate partner staged homicides.

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This presentation will make the forensic science community aware of the tactics intimate partner killers (IPKs) use to disguise homicides. Case histories will illustrate best practices to identify intimate partner (IP) staging tactics, and document, investigate, and prosecute these types of cases, thus discerning fact from fiction. Because IP homicide cases are often circumstance-dependent and involve diagnoses of exclusion, this specialized training is essential to uncover the truth, reach an accurate cause and manner of death, bring IPKs to justice, and ultimately improve public health outcomes. Participants will learn how IPKs disguise homicide as a nonsuspicious death (i.e. natural, accident, or suicide) or missing person case, setting in motion the potential misdirection of all the decision-makers in the life cycle of the case. Decision-makers include dispatchers, fire and EMS, law enforcement, criminalists, medical examiners, coroners, medical personnel, attorneys, judges, and juries. When homicide is obvious, investigators usually regard the victim's IP as a possible suspect, so an effective strategy for the IPKs is to make the death, from the outset, look like something other than a homicide. For example, homicidal asphyxia might be staged as a suicidal hanging. This underscores why we must always consider all manners of death, and confer with individuals experienced and trained in the dynamics of staged homicides, IP abuse, domestic violence, trafficking, and serial sexual predation. Anticipating that investigators will regard them as potentially culpable, caregivers who kill infants or young children in their care have also been known to disguise homicides as nonsuspicious. Such homicides can be more difficult to stage because investigators are more likely to place accountability on the caregiver in these cases due to the decedent's inherent dependence on them. For the deaths of teenagers and adults, however, investigators recognize that the decedent has agency, and as such may initially accept the nonsuspicious circumstances presented by a seemingly obliging and grieving IP. Decision-makers must remember a potentially manipulative IP knows the victim well, and is acquainted with their purported history and behaviors (e.g., natural disease processes, alcohol and drug use, and suicidal ideations). In fact, it is not uncommon for a victim of staged homicide to be a member of vulnerable populations. These populations include victims with a history of drug crimes and misuse, mental illness, unhealthy lifestyles, prostitution, or domestic violence. It is understandable that investigators might use this kind of social and behavioral history (often

presented to them by the IP killer) to justify the ruling of a nonsuspicious death. Trusting these first impressions and making correlative assumptions can engender confirmation bias, sending decision-makers down the wrong path, which can result in an unsafe and insufficiently supported cause and manner of death and jurisprudence outcome. Successful decision-makers will guard against this impulse, consider multiple possibilities, and actively seek out, examine, and verify all testimonial and physical evidence before coming to conclusions. This presentation will help attendees achieve this approach which can yield consistently effective investigations, accurate rulings regarding cause and manner of death, and justified jurisprudence outcomes.

Unravelling the Use of Urea Nitrate in Terrorist Attacks: A Forensic Perspective

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The devastating Easter Sunday bombings, targeting several hotels and churches in Sri Lanka in 2019, prompted an urgent forensic investigation to decipher the explosive composition, which revealed the insidious use of urea nitrate (UN). This study meticulously details the pivotal role of Gas Chromatography-Mass Spectrometry (GC-MS) in definitively identifying UN, a fertilizer-based improvised explosive, amidst the complex post-blast debris. The discovery of precursor materials—urea, nitric acid, detonators, and Christmas bulbs—in Wanathawilluwa, coupled with a precursory test explosion in Kaththankudy, foreshadowed the impending terror. However, the absence of prior UN-related incidents in Sri Lanka posed a formidable analytical challenge.

Recognizing UN's inherent instability and rapid decomposition, initial field tests utilizing colorimetric reagents p-dimethylaminocinnamaldehyde (p-DMAC) and p-dimethylaminobenzaldehyde (p-DMAB) were employed. However, definitive confirmation necessitated the deployment of high-resolution GC-MS, utilizing an Agilent 7890B GC system coupled with an Agilent MSD 5977A, and an HP-5MS column under optimized conditions. The resulting chromatograms from Wanathawilluwa, post-blast debris collected from the hotels, churches, and Kaththankudy consistently exhibited a distinct urea peak at 4.3 minutes. Crucially, library matching identified adjacent peaks as degradation products of UN, unequivocally confirming its presence. This robust analytical approach transcended the limitations of UN's instability, providing irrefutable evidence linking the explosive to the Easter Sunday attacks and preceding incidents.

Beyond chemical identification, the forensic investigation revealed the sophisticated use of improvised Christmas bulb detonators, highlighting the advanced planning and technical prowess of the perpetrators. This study underscores the indispensable role of advanced analytical techniques, particularly GC-MS, in counterterrorism efforts. The precise identification of UN not only provides crucial forensic intelligence but also strengthens national security by enhancing our understanding of terrorist methodologies and bolstering our capacity to prevent future attacks. This research serves as a testament to the power of forensic science in unravelling the intricate chemical signatures of terror.

Usefulness of Strontium Stable Isotope and Trace Metals Ratios for Sourcing Illicit Drugs

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Law enforcement agencies are faced with significant global challenge from illicit drug trade, this necessitates forensic techniques that can reliably attribute the geographic source of illicit drugs. Impurity analysis and alkaloid content have been relied on for traditional chemical profiling, variations in processing however affect these methods. On the contrary trace metals and strontium (Sr) stable ratios are conservative tracers with unique signatures that remain unchanged and unaffected by processing.

Though elemental and isotopic analysis have been widely used in archaeological and environmental sciences, their application in forensic profiling of illicit drugs remains underutilized. Recent studies in methamphetamine, marijuana, cocaine and heroin suggests that trace metals and Sr stable ratios can differentiate regional illicit drug production zones, but comprehensively evaluating their effectiveness in illicit drug profiling is needed.

This review examines the forensic applications of trace metals and Sr stable ratios, methodologies used and synthesizes recent findings. This provides important information regarding trafficking routes and trends of production to law enforcement agencies to enhance interdiction and eradication strategies.

Trace metals and Sr stable ratios provide unique fingerprint of illicit drug samples reflecting on the geographic and geological features of the regions of cultivation. There is a variation composition of trade metals depending on processing methods, soil composition and water resources, helping to differentiate production regions. Research on heroin and cocaine have indicated that samples geographic regions such as North and South America show distinct Sr isotopic signatures making them essential in the Cocaine Signature Program of the Drug Enforcement Administration's (DEA) for profiling drugs.

Veterinary Forensics in a Collection of Wildlife Crimes in the Greater Cape Town Area, South Africa

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Wildlife crime is the fourth most lucrative illegal global crime. The consequences of these crimes are biodiversity threats, legal economy disruption and costs of law enforcement. Veterinary professionals play a valuable role in evidence collection and documentation for the use in wildlife crime investigations. Case studies from the greater Cape Town, South Africa, area are discussed to highlight the extent of wildlife crime and the veterinary forensic involvement (wound analysis, DNA, ballistics, toxicology and radiographs) in these cases:

1. blunt trauma to a seal killed for its skin to be sold in the African traditional medicine market; post mortem with wound analysis

2. Projectile fatality of baboon in residential area; post mortem, wound analysis and radiographs
3. illegal pangolin transport and trade seizure destined for international export; wound analysis and veterinary care
4. projectile fatalities of rhinoceros with their horns removed for illegal trade in a game reserve: post mortem with projectile evidence collection and radiography
5. illegal shark fin seizure also destined for illegal trade; DNA with species identification.
6. Wilddog and vulture poisoning fatalities; toxicological analysis.

The audience will gain an insight into wildlife crime cases forensics techniques used in Southern Africa and have an appreciation for the situational working environments.

Poster Presentations

Collaborative Efforts to Identify Unidentified Human Remains Through DNA Extraction, Kinship Testing, and Forensic Genetic Genealogy

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Current projections indicate that there are roughly 40,000 unidentified human remains (UHRs) across the U.S. that have yet to be identified. The identification of UHRs is a critical challenge in forensic science, requiring innovative approaches and interdisciplinary collaboration. The West Virginia Forensic Genetic Genealogical Commission (WVFGGC) was formed for this reason. This initiative involved contributions from 24 agencies located in West Virginia, along with 7 additional agencies across the states of Ohio, Maryland, Tennessee, Texas, and Washington D.C. The goal of this project was to resolve 45 UHR cases through a collaborative, multi-agency approach with the West Virginia Forensic Genetic Genealogical Commission.

This multi-agency collaboration has provided answers for 35 families of unidentified persons. The WVFGGC enables testing of UHRs at MUFSC, helping reduce the WVOCME's backlog.

MUFSC validated the MiSeq FGx® system and is expanding its capabilities with additional platforms to improve complex UHR identification using FGG and next-generation sequencing. Incoming instrumentation to MUFSC includes the Illumina iScan®, Element Biosciences AVITI , and GridION sequencer. Adapting to evolving forensic needs and expanding the WVFGGC model nationwide can enhance case resolution and improve efficiency with UHR identifications. Cross-agency training initiatives can also strengthen collaboration and close knowledge gaps.

Ongoing innovation and partnerships have led to the receipt of 21 new UHR cases in 2025, with continued efforts underway to identify more remains through WVFGGC collaboration.

Crime Scene Photography with Mobile Devices

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In the early 2000s, mobile device cameras were unsuitable for forensic imaging and crime scene photography due to their limited functionality, low resolution, and poor low-light performance. By the mid-2000s, camera quality had improved with better resolution and autofocus, leading to the replacement of pocket-sized digital cameras for casual use. However, these early advancements did not resolve key issues for forensic use, such as insufficient resolution and poor low-light capabilities. By the mid-2010s, however, mobile device cameras saw significant enhancements in resolution, software-based improvements in low-light performance, and overall image quality. Today, mobile cameras are highly capable, offering multiple lens configurations and advanced features for both casual and professional use. Mobile device cameras function much the same way as Digital Single Lens Reflex (DSLR) cameras. They have a lens that focuses the light on a sensor that records the image. The image is stored in onboard memory on the device. Light is metered by a sensor, a lens can be focused, and the image data is stored as a file. The essentials of exposure value also remain the same. Depending on the device and the software application used, the photographer may have the ability to adjust various exposure settings to achieve the desired lighting.

However, key technical differences remain. Mobile cameras use smaller, fixed lenses compared to the larger, interchangeable lenses of DSLRs. Mobile devices also rely heavily on computational photography to simulate effects like shallow depth of field, which DSLRs achieve through physical aperture adjustments. And while the low light capabilities of these devices have improved, they still do not possess the robust ability of a DSLR to capture a sharp image in low light. Additionally, mobile devices often include features such as “Live Photos” (Apple) and “Motion Photos” (Android) that complicate the process of determining the “original” image. Image retrieval from mobile devices requires direct connection to a computer, unlike the SD cards used in DSLRs. Care must be taken to ensure the integrity of image metadata during the transfer process, and images should be securely stored and removed from the device to prevent unauthorized access.

With respect to the other photography fundamentals, the same rules that are used to operate a DSLR are applicable to a mobile device camera. The photographer should use an overall, midrange, and close-up approach to structure their photographic documentation of the scene. As with a DSLR, scales and placards should be used to give the scene and evidence a sense of organization and size. Composition and exposure guidelines are also the same.

Conclusion: A modern mobile device camera is well suited to taking high-quality images in normal lighting and normal circumstances. The mobile device camera will function well even in the early morning or early evening. But in periods of darkness, the mobile device camera will not

perform as well as a DSLR. One may also encounter difficulties obtaining examination-quality images with a mobile device camera.

Development and Validation of a GC-MS Method for Detecting Kerosene in Adulterated Diesel Fuel

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The adulteration of diesel with kerosene is a pervasive problem in Sri Lanka, particularly among commercial vehicle operators, driven by economic incentives and the lower cost of kerosene. This fraudulent practice not only results in significant revenue losses for regulatory authorities but also severely impacts engine performance, increases harmful emissions, and compromises fuel quality and longevity. Moreover, the altered combustion properties due to kerosene adulteration accelerate engine wear and tear, contributing to heightened environmental pollution. Therefore, a reliable, precise, and scientifically validated method for detecting and quantifying kerosene adulteration in diesel is crucial for effective regulatory enforcement and fuel quality monitoring.

This study presents a Gas Chromatography-Mass Spectrometry (GC-MS) based analytical method for the sensitive, specific, and reproducible detection and quantification of kerosene adulteration in diesel. A calibration curve, spanning adulteration levels from 30% to 80%, was developed to establish a quantitative relationship between adulteration levels and hydrocarbon composition. Through rigorous analytical trials, the peak height fraction of Undecane ($C_{11}H_{24}$), calculated as the ratio of Undecane peak height to the sum of Decane ($C_{10}H_{22}$), Undecane ($C_{11}H_{24}$), Dodecane ($C_{12}H_{26}$), Hexadecane ($C_{16}H_{34}$), and Heptadecane ($C_{17}H_{36}$) peak heights, was identified as the most reliable indicator. This parameter demonstrated a strong linear correlation ($R^2 = 0.9731$) with the percentage of adulteration, ensuring high accuracy and reproducibility.

The developed GC-MS-based method provides a robust and validated forensic tool for identifying and quantifying diesel adulteration with kerosene. Its application can significantly enhance regulatory enforcement, support forensic investigations, and aid law enforcement agencies in combating fuel fraud. Furthermore, this methodology has potential for broader forensic, industrial, and environmental applications, ensuring fuel compliance and protecting both engine performance and air quality.

Exploring the Efficacy of Alternative Organic Fingerprint Powders

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Fingerprints are one of the most significant pieces of evidence in forensic investigation due to their uniqueness and durability. Dusting for fingerprints at a crime scene has been a primary step in crime scene investigation since the first fingerprint powder was developed in the 1920s.

Fingerprint powders used today are commonly made from carbon black (colloidal carbon), lamp black, talc, kaolin, aluminum, metal flake, and dolomite. These elements were found to be the most adherent to latent prints, so they are commonly used in most non-magnetic powders. These elements are grinded together with a binder, usually iron powder, lycopodium, corn starch, rosin, and gum Arabic, to create a fine powder that will then be packaged and used to dust for fingerprints. A large volume of research, and practitioner experience, has proven the effectiveness of various common traditional fingerprint powders; however, current research has revealed health risks associated with their long-term use.

Organic powders are created from plants or other natural resources that have not been exposed to any chemicals. There are benefits to organic powders, they are environmentally friendly, non-toxic, and could potentially enhance the visualization of latent prints on challenging surfaces. With that being said, the realm of organic powders in comparison to traditional powders is highly unexplored.

This study evaluates the potential of organic powders as safe and inexpensive alternatives to conventional fingerprint powders. Traditional powders, such as carbon-based variants, have been linked to respiratory health risks when used over extended periods. Therefore, this research tests organic alternatives: turmeric, cinnamon, cocoa, and matcha powders to explore their effectiveness in fingerprint detection.

The research compares these organic powders against carbon fingerprint powder on three commonly encountered surfaces in forensic investigations: glass, aluminum, and ceramic tiles. The method involves collecting latent fingerprints from five individuals, dusting them with the respective powders using a feather brush, and capturing the developed prints using a Nikon D70 camera for analysis.

Results show significant variation in the effectiveness of the powders. Cocoa powder emerged as the best performer, providing the clearest ridge details across all surfaces, with an overall average score of 3.06 out of 4. Matcha also demonstrated promise with a 2.80 average, especially on glass and aluminum surfaces. In contrast, turmeric and cinnamon performed poorly, often failing to adhere properly to the fingerprints, scoring 1.53 and 1.73, respectively.

The study concludes that cocoa and matcha powders hold potential as organic alternatives to conventional powders, while turmeric and cinnamon are less viable. Future research should focus on refining the consistency of cocoa and matcha powders and testing prints left for extended periods to better simulate real-world crime scene conditions. This study provides valuable data that supports the ongoing search for safer, environmentally friendly alternatives to traditional forensic fingerprint powders.

Testing of Training Aid Validation Method for Standardization of Non-Detonable Training Aids

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Canines are increasingly used in explosives detection as they can overcome vapor detection and matrix limitations encountered by instrumental sensors. To train them effectively, they must be exposed to the odor profile of the explosive. However, most explosive materials are highly unstable and hazardous, preventing their direct use in canine training and necessitating the development of non-detonable training aids. With variation among commercially available and novel training aids, limited research exists on their verification and validation, making it essential to establish a standardized evaluation method. This research's goal is on developing and assessing a validation method for non-detonable training aids by analyzing their odor profiles through headspace solid phase microextraction (HS-SPME) and gas chromatography-mass spectrometry (GC-MS).

Studies have confirmed the headspace components of common explosives for training aid development, showing that odor profiles range from complex mixtures of multiple volatile organic compounds (VOCs) to simpler profiles with fewer target odorants. For example, hexamethylene triperoxide diamine (HMTD) has seven VOCs representing its odor signature, due to the parent compound's low vapor pressure and thermal stability. The developed validation method was applied to commercially available training aids and cellulose-based training aids prepared in our lab for HMTD. The headspace of each training aid was extracted using HS-SPME for one hour and analyzed via GC-MS. The method successfully detected all seven target compounds in the cellulose training aids and two of the target compounds in ScentLogix, a commercially available training aid tested. To further assess its effectiveness, the method was tested on a cellulose training aid spiked with dinitrotoluene (DNT), demonstrating its capability to accurately detect both target compounds and contaminants.

These findings support the reliability of this validation method in assessing the odor profiles of non-detonable training aids, providing a standardized approach to improving canine detection training for explosive materials.

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