



UNIVERSITY OF AMSTERDAM

Institute of Interdisciplinary Studies

Master Forensic Science

Research Projects 2022-2023



MASTER FORENSIC SCIENCE

Research projects 2022-2023

The University of Amsterdam's (UvA) Master's programme in Forensic Science, offered by the Faculty of Science, is unique in the Netherlands. The programme distinguishes itself from most international Master's programmes in Forensic Science by building on a range of scientific disciplines, such as Chemistry, Computer Science, Life Sciences, Mathematics, Physics, and other exact sciences. The goal of the programme is to train good scientists, armed with forensic knowledge and skills.

A part of the curriculum is a six-month internship during which scientific research is executed that is relevant to the forensic field. This document gives an overview of the capabilities of our students and the many ways in which a research project can be conducted.

For more information please contact:
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Title	Organisation	Student	Previous education
Crime Scene Science			
Investigating the added value of hyperspectral imaging during crime scene investigations	Police; Forensic investigation	Fieke Bron	Biotechnology
The Effects of Content and Timing of Contextual Witness Information on Ambiguous Crime Scene Investigations	Netherlands Forensic Institute (NFI)	Boukje Meester	Psychobiology
Criminalistics			
Speaking for the dead. A study into influences on decision making at the scene of death.	Police	Lot Claeys	Pharmaceutical Sciences & Drug Development
Does consideration of the network construction of interrelated dynamic risk factors increase the predictive accuracy of sexual reoffending?	Transfore	Daphne Jonkers Both	Medical Informatics
Digital Forensics			
The PRNU-based Camera Identification Method for Multi-camera Smartphones	NFI	Lot van Leeuwen	Applied Mathematics
Forensic Biology			
Proof-of-Concept for a microRNA Marker Assay for Forensic Body Fluid Identification using RT-qPCR	Univ. Lausanne	Linus Altman	Biomedicine
Examining the Variability Between RapidHIT ID Instruments Under Controlled Conditions and the Effects of the External Environment	University of North Texas Center for Human Identification	Angelo Figueroa	Biomedical Science
Investigation of the blood and brain metabolome of rats following cocaine intake	Aarhus University	Emaan Ghias	Biology
DNA loss and relocation during exhibit packaging and transport of undergarments	HvA	Oanelle Gléonec	Frontiers of Life: life sciences
Estimating time since deposition of saliva stains using nanopore sequencing of the human microbiome	HvA Nicolaes Tulphuis	Tara Griffith	Biochemistry
Identification of human remains in individual and mass graves: different strategies in forensic genetics	University of Eastern Piedmont	Moya McCarthy-Allen	Biological Sciences and Psychology
Where there is a strand, there is a way: Optimizing the PCR amplification of sedimentary ancient DNA to allow for successful sequencing	Naturalis	Liam Oskam	Biology
Recovery of Latent DNA from Knife Handles after Subsequent Handling by the Original User	AUAS	Fabio Tango Cañete	Human Biology

Title	Organisation	Student	Previous education
Forensic Biophysics			
Capturing post-mortem internal fingerprints using optical coherence tomography	UAMC	Ana Gutierrez Crispini	Genetics
The detection and quantification of albumin via a singleplex Proximity Ligation Assay (PLA) and quantitative PCR (qPCR)	UAMC	Anouk Kreuger	Biomedical Sciences
The Development of a Mobile Application For Post-Mortem Interval Estimation in Police Investigations	UAMC	Stijn van Lierop	Artificial Intelligence
Quantifying Concentration Levels and Affinity in Forensic Biosensors Using a Multi-Ring Resonator and Kinetic Data Modelling	UAMC	Ishan Schneider	Liberal Arts and Sciences: Mathematics/physics
Using Reflectance Spectroscopy for Bloodstain Age Determination in Wildlife Forensics in the Fight against Poachers	Wildlife Forensic Academy	Thomas Shehata	Chemistry
Forensic Chemistry			
Exploring distinguishing markers in chlorine gas and bleach-exposed concrete samples for forensic casework	TNO	Bence Dallos	Chemistry with management
Characterization of a portable NIR instrument for qualitative and semi-quantitative analysis of MDMA in ecstasy tablets	Trimbos	Tim Laning	Chemistry
Background and Transfer of KClO ₄ /Flash Powder	NFI	Sofie Lazeroms	BSc & MSc Chemistry
Predictive modeling of per- and polyfluoroalkyl substances (PFAS) in surface water using machine learning approaches	KWR	Xing Yu Pan	Beta-Gamma: artificial intelligence
Molecular networking of truxillines and other alkaloids for cocaine batch differentiation	Avans University of Applied Sciences	Karlijn Werkman	BSc en MSc Bio-Pharmaceutical Sciences

Title	Organisation	Student	Previous education
Forensic Medicine			
"Cognizance of Fire: Estimating exposure temperature of human bones using Fourier-Transform Infrared Spectroscopy	UAMC	Sienna Arnold	Biomedical Science
Evaluation of rapid forensic toxicology in the medico-legal death investigation process in Victoria, Australia	Victorian Institute of Forensic Medicine (VIFM))	Simona Gazzera	Chemistry
The Decision-Making of the Court in Criminal Cases of Grievous Bodily Harm in 2022 in the Netherlands	GGD Amsterdam	Mus Leijtens	Psychobiology
Sodium azide/nitrite suicides in the Netherlands between 2015 and 2022	GGD Amsterdam	Dominique van Pelt	Biomedical Sciences
Transcriptomic characterization of cytochrome P450 isoforms in hepatic cell models – the metabolism of benzodiazepines as a case study	VU	Rita Raymundo Carlota	Biochemistry
Gunshot Trauma and Osteonal Damage in Human Long Bones	Universitat Autònoma de Barcelona, Institut de Medicina Legal i Ciències Forenses de Catalunya, Unitat de Medicina Legal i Forense.	Keira Sexton	Biomedical Sciences
Age-at-death estimation from costal cartilage ossification patterns in elderly White South Africans using Lodox® scans	AMC	Lufuno Tshivhase	Biological Sciences: Human Anatomy and Experimental Physiology
Forensic Statistics and Mathematics			
A comparison of the TopDown approach with EuroForMix for the analysis of DNA mixture profiles	NFI	Dion van der Meulen	Applied Mathematics
Further Development and Evaluation of an mRNA-based Model for Calculating Likelihood Ratios of Body Fluid Presence in Forensic Mixtures	NFI	Aafje van de Rijdt	Applied Mathematics

Crime Scene Science

Student	Fieke Bron
<i>Research carried out at</i>	Police; Forensic investigation
<i>Supervisor</i>	Raoul de Graaff BSc
<i>Title thesis</i>	Investigating the added value of hyperspectral imaging during crime scene investigations
<i>Abstract</i>	<p>Biological traces are often encountered during crime scene investigations and can provide information about the actors and activities related to a criminal act. These biological traces include human body fluids such as saliva, sweat, nasal fluid, vaginal fluid and urine which have been investigated in this research. Current used optical techniques to detect biological fluids like forensic light sources do not have the ability to discriminate between the biological stains and other non-biological fluorescent substances. There is a need for non-destructive, non-contact, non-invasive, rapid, on-site visualization technique, such as hyperspectral imaging. This technique should be suitable for use with different kind of backgrounds, since crime scene investigations have shown that some traces are very difficult to detect on certain background fragments. The goal of this feasibility pilot research is to investigate if hyperspectral imaging can contribute and be used as a rapid on-site non-destructive identification device for the detection and identification of five body fluids on four background colors: white, black, green and red. Spectral signatures of the body fluids were obtained with a fluorescence spectrometer. The high intensity fluorescent regions remained stable throughout the different cotton colors. For saliva, nasal fluid and vaginal fluid, a high intensity region around 280 nm excitation and 335 nm emission was consistently visible and did not change over time. Sweat and urine showed a more unique broader pattern at some higher wavelengths, around 400-500 nm. Next, the current method used by forensic crime scene investigators, the Crime-lite 82S together with a Nikon D7200 (280-700 nm), was compared to the Specim FX10 hyperspectral camera (400-1000 nm) being illuminated by the Crime-lite 82S. For all colored cotton samples, sweat was the easiest body fluid to distinguish with a distinguishable peak around 465 nm with the violet (395-425 nm) illumination source. Urine was distinguishable under a blue (420-470 nm) illumination source with a signature present around 500 nm. The background color has a major influence on the detectability of the traces and on the spectrum of the trace, further research is required to use the hyperspectral imaging technique at crime scene investigations.</p>

Student	Boukje Meester
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	dr. Madeleine de Grijter
<i>Title thesis</i>	The Effects of Content and Timing of Contextual Witness Information on Ambiguous Crime Scene Investigations
<i>Abstract</i>	<p>Crime scene investigation is a crucial first step in the forensic investigation chain, as during this process it is determined which traces are collected and secured for further forensic analysis. This decision-making at the crime scene can be influenced by contextual information that crime scene examiners receive. Compared to forensic analyses, however, much less guidelines exist on how to handle contextual information during these investigations, leading to large differences between individual crime scene investigators and a great susceptibility to cognitive biases. Contextual witness information is one of these types of information and, although presumed to be irrelevant to the specific investigative task at hand, has the potential to bias the crime scene investigator and influence the investigation. This study examined the effects of content and timing of contextual witness information on crime scene investigations. The results of the study were analysed using the Bayesian statistical framework and show no effect on traces or clues mentioned and used by participants, and very little effect on the interpretation of these traces or clues. Further research is required to enhance understanding of the risks and usefulness of contextual information in crime scene investigations and to develop applicable guidelines and best practices to mitigate cognitive biases at the crime scene.</p>

Criminalistics

Student	Lot Claeys
<i>Research carried out at</i>	Police
<i>Supervisor</i>	Merel van Cooten MSc
<i>Title thesis</i>	Speaking for the dead. A study into influences on decision making at the scene of death.
<i>Abstract</i>	<p>Death investigation is a critical field that aims to determine the manner and circumstances of one's death. However, there is a limited understanding of the factors that influence decision-making in this area, particularly in terms of scenario thinking. Moreover, there is yet very limited knowledge on the use of scenario-tools in death investigations. This study aimed to explore the factors that impact the construction of hypotheses and scenario thinking in death investigations, as well as whether a scenario-guided application could enhance this process. The study involved the evaluation of 46 real-life cases at the Dutch Police, of which 10 were observed on the scene itself. Additionally, a mock death investigation was conducted, involving 45 forensic and tactical investigators employed in the department of Midden-Nederland split into a control group (22 participants) and an experimental group (23 participants). The experimental group used a web application developed by the Dutch Police as an additional guide on scenarios for answering what could have happened. The findings of the study indicated that investigators recognized the importance of scenario thinking in theory and practice but faced challenges considering all hypotheses for the manner of death in real-life situations. Investigators disregarded the possibility of a felony in 28% of the cases, which had a significant impact on their investment in the investigation, resulting in a quicker abandonment of additional investigational techniques. The study identified prior perceptions, steering start information from police officers, and context information such as age of the deceased as potential factors that can influence the construction of scenarios. Finally, the experimental group in the mock death investigation constructed a significantly higher number of scenarios (M = 5,78 vs. 4,73) and showed significantly higher confidence in their chosen most probable scenario. The results of this study emphasize the crucial role of the forensic community in conducting objective and impartial investigations, while highlighting the need for proper training of investigators to recognize and address the influence of biases in their work. Moreover, the results of this study suggest that the developed web application has great potential as a valuable addition to death investigation practice.</p>

Student	Daphne Jonkers Both
<i>Research carried out at</i>	Transfor
<i>Supervisor</i>	Jan Willem van den Berg
<i>Title thesis</i>	Does consideration of the network construction of interrelated dynamic risk factors increase the predictive accuracy of sexual reoffending?
<i>Abstract</i>	<p>Sexual offenses, such as rape and sexual assault, cause severe harm to victims, their families and society as a whole. Effective treatment of and management strategies for men with a history of sexual offenses are therefore crucial in preventing any further instances of sexual offenses. A pivotal precondition for this is the accurate risk assessment of sexual reoffending. However, the predictive validity of current instruments remains an ongoing challenge. To contribute to a safer society, this study investigates to what extent the predictive validity of sexual reoffending increases by considering the risk factors of sexual reoffending from a network of interrelated dynamic risk factors. Method: Data on dynamic risk factors of adult men charged or convicted for at least one sexually motivated offense in North America (N = 5,314) as measured by the Stable-2007 were used to compare the predictive accuracy of the regular approach of risk assessment to a network-based approach. For the regular approach, a logistic regression of the sum score of dynamic risk factors was employed. In the network-based approach, sexual reoffending was predicted by all dynamic risk factors using nodewise predictability (Haslbeck & Waldorp, 2017). To accurately determine the predictive validity of both models, the dataset was split at a [20:80] ratio repeated over 300 iterations, resulting in 300 datasets consisting of a random training sample (n = 3,579) and test sample (n = 895). To compare the approaches, the AUC of both approaches were calculated for each of the 300 test samples. Results: The mean AUC of the regular sum score approach was .67 (SD = .04 [.46-.76]), while the mean AUC of the network-approach appeared to be .50 (SD = .03 [.48-.53]). Discussion: The research findings showed that the network-based approach did not outperform the regular approach. However, this can be attributed to the cross-sectional nature of our data and the fact that our analysis was conducted at a group level. Therefore, we maintain belief that the NBM-RSR holds when employing an alternative approach resulting in individual networks for each male with a history of sexual offense. Further research should justify our belief.</p>

Digital Forensics

Student	Lot van Leeuwen
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	dr. Arjan Mieremet
<i>Title thesis</i>	he PRNU-based Camera Identification Method for Multi-camera Smartphones
<i>Abstract</i>	<p>The Photo Response Non-Uniformity (PRNU) based camera identification method has proven to be a viable and powerful method for single cameras to identify the source camera that took the photo. This research investigates this PRNU-based camera identification method in the context of multi-camera smartphones. It explores the effectiveness and camera module attribution of the PRNU-based method for two modern multi-camera smartphone models: the Samsung Galaxy A52 and the iPhone 13 Pro Max. To assess the method's effectiveness, experiments were conducted in various surroundings, zoom modes and settings. The results indicate that, for the Samsung Galaxy A52, the method performs better when the setting High Dynamic Range (HDR) is disabled across all zoom modes. For the iPhone 13 Pro Max, the method demonstrates high reliability for photos taken in the 1x zoom mode but shows limitations in the 0.5x zoom and 3x zoom mode. Furthermore, the attribution of the multiple camera modules on the PRNU pattern present in a photo was researched. The analysis revealed for the Samsung Galaxy A52, that the no zoom 12MP, no zoom 64MP and 2x zoom modes exclusively use the Wide camera module, the 0.5x zoom mode exclusively employs the Ultra Wide camera mode and the macro mode solely relies on the Telephoto camera module. For the attribution of the iPhone 13 Pro Max it is suspected that only the Wide camera module is utilized in the no zoom mode. However, the exact attribution remains uncertain due to the inability to extract the PRNU patterns of separate camera modules. Overall, this study offers valuable insights for optimizing and applying the PRNU-based method in forensic investigations involving these smartphone models.</p>

Forensic Biology

Student	Linus Altman
<i>Research carried out at</i>	University Lausanne
<i>Supervisor</i>	dr. Diana Hall
<i>Title thesis</i>	Proof-of-Concept for a microRNA Marker Assay for Forensic Body Fluid Identification using RT-qPCR
<i>Abstract</i>	<p>With this proof-of-concept study, we aim to show that miRNA markers can be used for forensic body fluid identification. MiRNAs are a promising alternative to mRNAs, as they have been observed to be more stable and resistant to environmental influences than mRNAs. Through thorough literature search we identified miRNAs with potential for the identification of peripheral blood, skin contact traces, menstrual blood, saliva, semen and vaginal secretion. We used RT-qPCR for the evaluation of target expression in body fluid samples and subsequently built a Partial Least Squares – Discriminant Analysis (PLS-DA) model for the classification of unknown samples. Two different data processing methods were followed, as we built one training set with calibrated normalized relative quantities (CNRQ) and one with ΔCt values. Both training sets were subjected to statistical analysis with PLS-DA and their performance was assessed. We could observe that the ΔCt based dataset produced more reliable results than the CNRQ based dataset. Furthermore we succeeded at classifying unknown samples with our model and therefore demonstrated the feasibility of a miRNA based body fluid identification assay in our laboratories, confirming the results of previous studies conducted in this field. Future exploration and validation studies will enhance these findings.</p>

Student	Angelo Figueroa
<i>Research carried out at</i>	University of North Texas Center for Human Identification
<i>Supervisor</i>	dr. Michael Coble
<i>Title thesis</i>	Examining the Variability Between RapidHIT ID Instruments Under Controlled Conditions and the Effects of the External Environment
<i>Abstract</i>	<p>Given the combination of relative reliability, ease of use and speed seen in Rapid DNA instruments, it is no surprise that there has been a rapid increase in their usage in laboratories across the world over the past few years. Multiple agencies worldwide intend to use these instruments in settings outside of the typical laboratory, such as in mobile laboratories or temporary outdoor facilities, although most of these have some form of environmental control. While validation studies for Rapid DNA Systems have been completed to ensure their reliability and efficacy in controlled settings, there are minimal available data specifically focused on assessing any potential variance between instruments or testing their reliability in uncontrolled outdoor conditions.</p> <p>This primary aim of this study is to determine the level of variance seen between RapidHIT ID instruments regarding their total signal output alongside the peak height ratios. Specifically, the goal is to determine if separate instruments under typical laboratory conditions produce significantly varying results from near-identical sample sources, and if one of the major interchangeable components, namely the primary cartridge, potentially effects the results of these instruments. The secondary aim is to determine if the instruments can properly function in an outdoor environment with no notable forms of environmental controls and can provide accurate and reliable results in such conditions.</p> <p>The results show that there was only a significant level of variation in the total signal output between instruments installed with different primary cartridges, with an average total signal difference of ~1,100 RFUs with a p-value of 0.0007, but no significant difference in the peak height ratio. Instruments installed with the same cartridge showed no significant variation. Finally, the instruments were able to function in a limited capacity in an outdoor environment, with the main limiting factor being the ambient temperature. However, the instruments were able to consistently produce full profiles at similar levels to those in the lab, at the cost of a noticeably higher error rate.</p>

Student	Emaan Ghias
Research carried out at	Aarhus University
Supervisor	dr. Mogens Johannsen
Title thesis	Investigation of the blood and brain metabolome of rats following cocaine intake
<p data-bbox="185 371 288 394">Abstract</p> <p data-bbox="185 1055 424 1077">Created using Biorender</p>	<p data-bbox="831 371 1410 1825">Toxicological analysis is an essential part of many forensic investigations concerning drug-related deaths and illicit drug use. Recently, metabolomics has been applied in forensic toxicological research as it allows the comprehensive analysis of endogenous and exogenous metabolites and helps to understand the changes a biological system undergoes in response to a stimulus. Cocaine is an illicit drug that is one of the most commonly abused stimulants in Europe and has devastating physiological and neurological effects that warrant novel research into its metabolism and biomarkers of toxicity. In this study, an untargeted metabolomics approach using ultra-high performance liquid chromatography high-resolution quadrupole time-of-flight mass spectrometry (UPLC-HR-QTOF-MS) was employed to investigate the endogenous metabolic changes that occur in the blood and brain tissues of rats following cocaine intake. Using univariate and multivariate statistical analyses, along with Pearson correlation analysis, the impact of cocaine on the metabolic profiles of the two matrices was evaluated. The results indicate that amino acid metabolism, bile acids, purine metabolism, and carnitine metabolism are affected. Specifically, tyrosine is dysregulated, as well as metabolites in the tricarboxylic acid cycle (TCA cycle), hypoxanthine, inosine 5'-monophosphate (IMP), guanosine 5'-monophosphate (GMP), short-chain acylcarnitines, glycocholic acid, and glycochenodeoxycholic acid. In both tissues, amino acid metabolism, purine metabolism, intermediates of the TCA cycle, and the reduced to oxidized glutathione ratio are significantly altered. While most of the findings are a result of cocaine's effect as an appetite suppressant, they may still contribute to expanding current forensic toxicological marker panels and working towards a better understanding of the mechanism of toxicity of cocaine.</p>

Student	Oanelle Gléonec
<i>Research carried out at</i>	HvA
<i>Supervisor</i>	dr. Bas Kokshoorn
<i>Title thesis</i>	DNA loss and relocation during exhibit packaging and transport of undergarments
<i>Abstract</i>	<p>In sexual assault cases, the retrieved DNA quantity and sampling location from the victim's underwear can be a precious source of information about the nature of the (alleged) contact with the person of interest. However, previous research has shown that the packaging and transport of crime scene samples may cause the transfer of DNA from the exhibit to the packaging and other areas of the same item. This research analysed the influence of packaging on DNA loss and relocation to aid the analysis of DNA evidence at an activity level for casework purposes.</p> <p>This study reaffirms that DNA relocation happened in every type of packaging (breathable evidence bag, paper bag, sterile sheet) and for both source DNA materials investigated (saliva, touch DNA). While more DNA is retrieved on underwear with saliva deposits, higher transfer rates for touch DNA were observed. Overall, all packaging shows similar transfer proportions with the exception of a lower transfer rate to another area while packaging underwear with a saliva trace in a paper bag. Nonetheless, only DNA retrieved from the deposit location yielded a DNA quantity sufficient for STR-typing.</p> <p>These findings underline that none of the investigated packaging types promotes or reduces DNA loss or relocation when compared to each other. Determining the origin of the transferred DNA (background versus deposited DNA) remains to be elucidated.</p>

Student	Tara Griffith
<i>Research carried out at</i>	HvA Nicolaes Tulphuis
<i>Supervisor</i>	dr. Mohamed Hamdi
<i>Title thesis</i>	Estimating time since deposition of saliva stains using nanopore sequencing of the human microbiome
<i>Abstract</i>	<p>The human microbiome is diverse as it can be influenced by many factors such as bioancestry, age, health, lifestyle, hygiene, recent travel, nutrient availability, oral antibiotic use, and diet (Sijen et al., 2021; Schmedes et al., 2018; Neckovic et al., 2020). An environmental microbiome is also diverse and therefore it is supposed that once a biological stain has been deposited on a crime scene, its bacterial makeup will be influenced by the environment and the time of deposition. Determining the time since deposition (TSD) of a stain is useful for forensic investigation for evaluating the alibis of potential suspects, narrowing down traces which may be most relevant for further investigation (based on the suspected timeline of the crime), and determining the post-mortem interval (PMI) (Díez et al., 2021). This research project therefore aims to answer the question: is it possible to estimate the TSD of a saliva stain using nanopore sequencing of the human microbiome? <i>Fusobacterium periodonticum</i> and <i>Haemophilus parainfluenzae</i> were selected to be analyzed in the saliva over time because these were determined to be two of the more relevant and abundant bacterial species in saliva (Díez et al., 2021). Saliva samples obtained from three different female donors were aged over time, saliva stains were isolated on 7 different time points, targeted barcoded PCR was done, and sequencing was conducted using the MinION Flongle nanopore sequencing device. The relative abundance of each bacterial species, as well as the ratio between the two bacterial species, were analyzed. The findings showed that the TSD ratio between <i>Fusobacterium periodonticum</i> and <i>Haemophilus parainfluenzae</i> increases initially, reaching a peak at day five, and then proceeds to decrease. Overall, this pilot study showed promising results and the methods developed for estimating TSD using nanopore sequencing should be tested with a larger dataset to determine if the trends are consistent between individuals.</p>

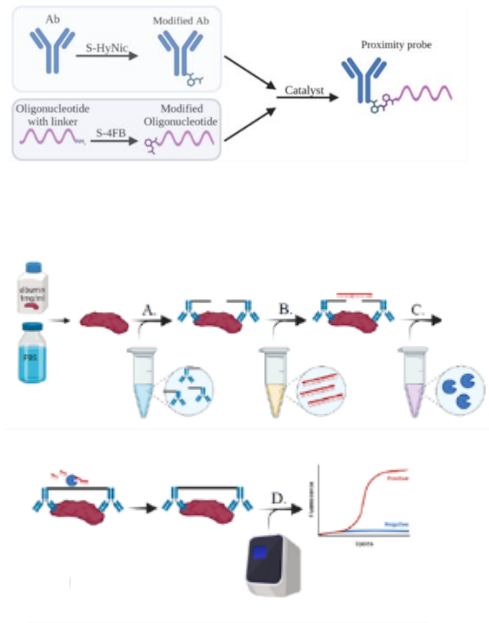
Student	Moya McCarthy-Allen
<i>Research carried out at</i>	University of Eastern Piedmont
<i>Supervisor</i>	dr. Sarah Dino
<i>Title thesis</i>	Identification of human remains in individual and mass graves: different strategies in forensic genetics
<i>Abstract</i>	<p>Identification of human remains in clandestine mass graves poses a challenge to forensic investigations. Development and validation of strategies addressing this challenge requires an understanding of the taphonomic processes underpinning the spatial and biomolecular layout of mass graves. Current scientific knowledge is limited in this regard. However, to avoid risking the legal acceptance of evidence, such research and strategy development cannot be conducted during forensic casework. Currently, DNA sampling from decomposed human remains is performed from hard tissues (bone and teeth), through labor-intensive, expensive methods. As part of the “Mass Grave Project” (MGP) conducted at the Forensic Anthropology Center at Texas State University, the viability of DNA profiling from soft tissues for identification in mass burial contexts is investigated. If equally valuable genetic information can be obtained from soft tissues as hard tissues, cheaper, more efficient DNA sampling methods may be developed. In the MGP, one mass grave with six commingled human donations and three individual graves underwent an 18-month burial. This controlled experimental design enabled deeper analysis of differential decomposition, tissue-type, DNA contamination, grave location, and grave type with respect to the DNA results. Pre-burial, human donations were preserved frozen, as is common in forensic taphonomy research. However, understanding the effects of fresh-freezing bodies on DNA is important regarding the suitability and validity of using human donations in genetic research post-freezing. This sub-study of the MGP analysed the DNA results of neck, oral and rectal swabs collected at each timepoint as well as swabs from contact points between human remains in the mass grave. DNA profile quality decreased across all three timepoints. The results firstly challenge the suitability of using human donations post-freezing for genetic research. Further, differential macroscopic tissue decomposition was observed within and between individuals in the mass grave, supporting previous observations of this phenomenon. However, this was not dependent on a bodies position in a grave, and was also observed within bodies in individual graves. Importantly, the DNA results were not dependent on the degree of tissue decomposition (macroscopic) nor the location of a body within the grave. However, as expected, no DNA results were reported in the samples analysed in this study that were collected from skeletonised human remains. In the mass grave, indications of DNA cross contamination were observed, as well as higher levels of human DNA preservation relative to the individual grave. Despite this, post-burial DNA profiling success was limited at these sampling locations. The results extend forensic awareness into the effects of freezing and burial on genetic identification. This information aids in the ultimate pursuit of developing improved investigative strategies for genetic identification of individuals in mass graves. From the results of this study, several recommendations for forensic practice and future research are made.</p>

Student	Liam Oskam
<i>Research carried out at</i>	Naturalis
<i>Supervisor</i>	ir. Barbara Gravendeel
<i>Title thesis</i>	Where there is a strand, there is a way: Optimizing the PCR amplification of sedimentary ancient DNA to allow for successful sequencing
<i>Abstract</i>	<p>Sedimentary ancient DNA (sedaDNA) is a relatively new topic of interest in the fields of biodiversity, ecology and evolution, and other fields are slowly opening up to the potential of this source of genetic information. The rather ubiquitous nature of environmental DNA allows for studies to be conducted on material that is not visible to the eye in ecological, evolutionary, archaeological and forensic contexts. The ability to sequence moderately to highly degraded material from within the environment could help increase the applicability of forensic botany in modern casework for instance. An issue plaguing the field of sedaDNA analyses however, is the fact that this DNA is often quite fragmented, as well as surrounded by compounds that inhibit PCR amplification. This study focuses on comparing different amplification protocols based on established and novel options, to assess which amplification protocol is the most efficient and cost-effective in amplifying sedimentary ancient material and thus optimize the current amplification process. For this optimization, DNA from samples taken during archaeological research from Dutch grave contexts stemming back to around the 17th and 18th centuries was amplified using different protocols, for the purpose of assessing the effect of different Taq polymerases, annealing temperatures, additive concentrations and PCR cycles. It was found that protocols based on Thermo Fisher's Phire product line performed best overall, whilst also introducing a price decrease compared to currently used protocols. These protocols performed best when using 35 PCR cycles in the first PCR step, and at an annealing temperature of 60°C. Considering there is a desire from geneticists working with sedaDNA to establish a more standardized workflow that encapsulates both the practical laboratory work as well as the data analysis pipeline and reference database establishment, this research could be a valuable asset to adapt into said workflow, helping to improve amplification efficiency whilst also decreasing the budget required to perform future sedaDNA metabarcoding studies.</p>

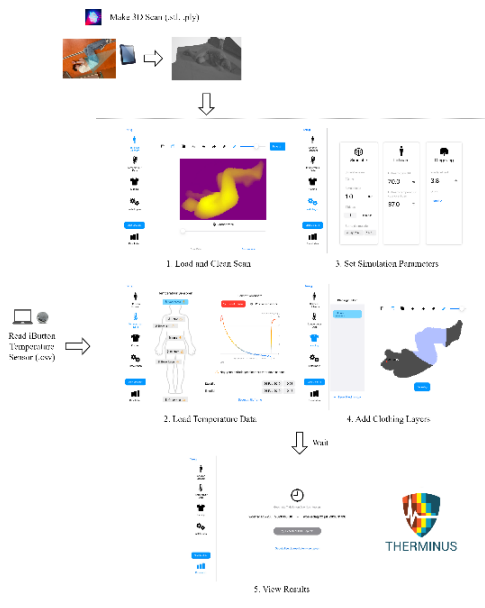
Student	Fabio Tango Cañete
<i>Research carried out at</i>	AUAS
<i>Supervisor</i>	dr. Bas Kokshoorn
<i>Title thesis</i>	Recovery of Latent DNA from Knife Handles after Subsequent Handling by the Original User
<i>Abstract</i>	<p>The relationship between biological traces and activities is increasingly debated due to the emerging optimisation in DNA profiling methods. A plethora of studies investigate various aspects of trace dynamics like transfer, persistence, prevalence, and recovery (TPPR). One aspect that is frequently encountered in casework but not well studied is the recovery of DNA from a person of interest after an item was handled briefly by one person and subsequently used by the regular user. This scenario is reflected in a 2004 case in Florida, where the stabber allegedly stole the knife from its regular user and the regular user briefly handled the knife after it was used to stab two victims.</p> <p>The purpose of this study was to recreate the relevant scenarios in this case under lab- controlled conditions. Additional variables were introduced given the lack of information regarding the case circumstances, such as swabbing the knives in situ and varying the subsequent holding action.</p> <p>Eight participants were recruited for this study and separated into four pairs, each consisting of one male and one female. First, participants produced regular use of the knives at home. At the lab, the other participant from the pair would stab a cardboard box thirty times with one of these knives, and subsequently, the original user would hold the knife again.</p> <p>Analysis revealed that shedder status varied significantly among individuals, and this may have influenced the higher contribution of DNA from high shedders compared to low shedders in mixed DNA profiles, regardless of whether they were the stabbers or the regular users. In general, regular users contributed more DNA to the DNA mixtures when compared to the stabbers. The low DNA quantities recovered from the knife handles indicate that the knife handle material could have minimized DNA transfer.</p> <p>This study provides additional knowledge in this type of stabbing scenario, which could help evaluate proposed hypotheses in cases with similar characteristics. More DNA-TPPR data should be generated investigating variables that significantly impact DNA-TPPR, and this data should be made internationally available to facilitate the infrastructure for activity level analysis in forensic investigations.</p>

Forensic Biophysics

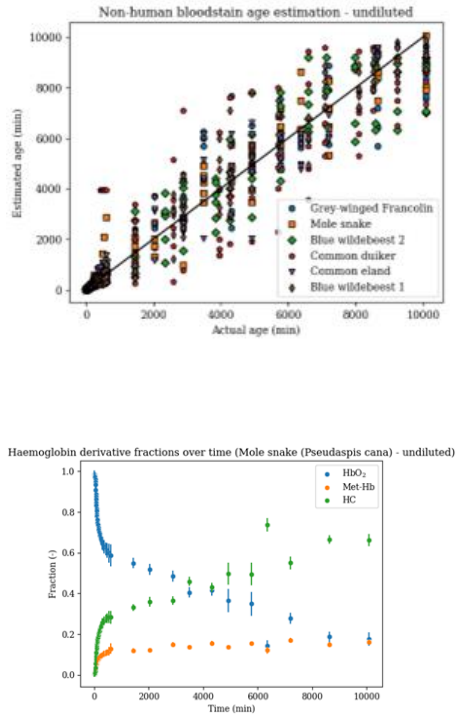
Student	Ana Gutierrez Crispini
<i>Research carried out at</i>	AUMC
<i>Supervisor</i>	Leah Wilk MSc
<i>Title thesis</i>	Capturing post-mortem internal fingerprints using optical coherence tomography
<i>Abstract</i>	<p>Fingerprints are the fastest and easiest identifier to use during victim identification efforts, however their use is largely limited by the integrity of the surface of the skin. For years the internal fingerprint has been recognised as a valuable tool for identification when the surface print is not available, but few methods have been developed to exploit this feature. Optical Coherence Tomography (OCT) is a non-invasive high-resolution cross-sectional imaging technique that allows the visualisation of both the surface and the internal fingerprint.</p> <p>This research builds on unpublished work within the Forensic Biophysics research group of the Amsterdam UMC, with the goal of improving the current methods of post-mortem OCT extraction of internal fingerprints for identification purposes. Given that the use of this technique for post-mortem fingerprinting is still in its early stages, this study aims to broaden our understanding and optimise the application of OCT in extracting internal fingerprints. The study specifically examines the impact of sample type, namely whole hands and isolated fingers, on the preservation of the epidermal structures necessary for internal fingerprint extraction. Furthermore, the study compares the imaging capabilities of two different polarisation sensitive detectors within the OCT system, denoted as sensor 0 and sensor 1, as well as the combination of the two. The results of the study show that the extracted fingerprints from both sample types exhibit comparable internal fingerprint preservation. The analysis also shows that ridge and valley profiles are more distinct in individual sensor scans than in combined scans. Additionally, despite the fact that Camera 0 appears to enhance contrast for internal layers while Camera 1 appears to improve contrast for the skin's surface, statistical analysis reveals no significant difference in the optimal fingerprint depth between the two sensors. Overall, this study makes contributions to improving post-mortem OCT internal fingerprint extraction methods, which has significant implications for the forensic field. The findings of this thesis serve as stepping stones for the optimisation of OCT extraction of post-mortem internal fingerprints, paving the way for further development in the field to ultimately enable improved and extended identification of deceased individuals through post-mortem internal fingerprinting.</p>

Student	Anouk Kreuger
Research carried out at	UAMC
Supervisor	dr. Annemieke van Dam
Title thesis	The detection and quantification of albumin via a singleplex Proximity Ligation Assay (PLA) and quantitative PCR (qPCR)
<p data-bbox="185 371 288 405">Abstract</p> 	<p data-bbox="699 371 1410 913">The analysis of the chemical profile derived from fingerprints plays a crucial role in forensic investigations. Valuable conclusions can be drawn by evaluating specific characteristics of the donor, often assessed through biomarkers. However, these biomarkers are typically found in trace amounts, necessitating the use of highly sensitive detection methods. The use of a proximity ligation assay (PLA) meets these requirements and offers a promising solution. In a PLA, matched antibody pairs are linked to oligonucleotides to create proximity probes (PPs). When these probes bind to the biomarker, a connector oligonucleotide hybridizes to the free ends of the oligonucleotides. Subsequently, enzymatic DNA ligation joins the probes, generating an amplifiable template for quantification of the biomarker using quantitative polymerase chain reaction (qPCR).</p> <p data-bbox="699 920 1410 1249">The PPs were successfully generated and verified using gel electrophoresis with subsequent Silver and GelRed staining. Optimization of various steps in the PLA revealed that pre-amplification is necessary to reduce the Ct value, thereby increasing specificity. Based on the results, the optimal quantification steps involve the use of 0.4 μM concentrations for both forward and reverse primers, as well as 100 μM of the connector oligonucleotide. Additionally, an annealing temperature of 53.6 degrees celsius has proven to be effective.</p> <p data-bbox="699 1256 1410 1487">The current protocol demonstrates the feasibility of detecting albumin via PLA and quantifying it using qPCR. However, further optimization is required to enhance the protocol's specificity and sensitivity. This optimization should include determining the probe-to-biomarker ratio. Given the significance of detecting biomarkers accurately in forensic analysis, these efforts to optimize the protocol are essential.</p>

Student	Stijn van Lierop
Research carried out at	UAMC
Supervisor	Leah Wilk MSc
Title thesis	The Development of a Mobile Application For Post-Mortem Interval Estimation in Police Investigations
Abstract	<p>Accurate and precise estimation of the post-mortem interval (PMI), or the time since death, can be of high importance in forensic investigations in order to establish a timeline of events. The current standard method for PMI estimation is based on body core temperature, environmental temperature and body weight, and is often depicted as a nomogram. However, this method results in large intervals and makes use of subjective correction factors. Therefore, the Therminus model has been developed, a new PMI estimation method which simulates cooling using an individualized volumetric representation of the body created from a photogrammetry scan. The Therminus model has been shown to provide more accurate and precise PMI estimates. However, the method still involves many components and performing photogrammetry requires skill as well as a significant amount of time. As a result, the method is still relatively impractical for large-scale use on the crime scene. Therefore, the aim of this research was to implement the Therminus model in a mobile, single-device iOS application that can be easily used by crime scene investigators from the Dutch police on the crime scene. To this end, an app was designed and it was investigated how the model could be efficiently built in a mobile iOS environment. Furthermore, it was tested how the Light Detection and Ranging (LiDAR) sensors in the new Apple iPad Pro models can be incorporated into the workflow of the app to reduce the time it takes to create an individualized volumetric representation. A first prototype of the app was validated using data from four crime scenes and results were compared to the original Therminus model as well as to the current standard method for PMI estimation. Results show that the app performs similarly to the original, validated Therminus model and obtains superior precision and accuracy compared to the current standard method. However, reproducibility and repeatability of the method should be improved as PMI estimates still vary between and within users. This variance in PMI estimates can be attributed to the creation of the individualized volumetric representation of the body and possibly the placement of the temperature sensors in this representation. It is therefore recommended that the app is further developed and tested with crime scene investigators, not only to improve usability but also to find a standardized, repeatable and reproducible protocol for creating an individualized volumetric representation of a body. Nevertheless, when further developed, the Therminus app has the potential to become the new standard method for PMI estimation on the crime scene.</p>



Student	Ishan Schneide
<i>Research carried out at</i>	UAMC
<i>Supervisor</i>	dr. Annemieke van Dam
<i>Title thesis</i>	Quantifying Concentration Levels and Affinity in Forensic Biosensors Using a Multi-Ring Resonator and Kinetic Data Modelling
<i>Abstract</i>	<p>In cases of a poor-quality fingermark or when no reference fingermark is present in the database, examination of chemical traces in the fingermark can help narrow down the list of potential suspects. A Multi-Ring Resonator (MRR) offers a method to analyze compounds by detecting analytes by leveraging the interaction of these analytes with receptors to create binding sensorgrams. This study aims to determine the concentration of injected analytes, association rate, dissociation rate, and binding affinity by constructing a one-to-one kinetics model and calibration curves for MRR data. Successful estimation of association and dissociation rates was achieved when the concentration of injected analyte was known and vice versa. The estimation of the dissociation constant (K_d) proved functional for evaluating binding affinity. Establishing calibration curves resulted in a reliable relationship between analyte concentration and response, but caution is advised with selecting a concentration range with minimal sample injections. Future research should optimize the modelling approach by including additional parameters and focusing on estimating affinity values for specific kinetic interactions. Improved accuracy of the constructed kinetic model and calibration curves can be achieved with more experimental MRR data and the utilization of biosensor chips with additional rings.</p>

Student	Thomas Shehata
Research carried out at	Wildlife Forensic Academy
Supervisor	dr. Greg Simpson
Title thesis	Using Reflectance Spectroscopy for Bloodstain Age Determination in Wildlife Forensics in the Fight against Poachers
<p data-bbox="185 409 288 432">Abstract</p>  <p data-bbox="185 1048 643 1070">Haemoglobin derivative fractions over time (Mole snake (<i>Pseudaspis cana</i>) - undiluted)</p>	<p data-bbox="668 416 1410 1429">Every year, approximately 350 million animals are killed or trafficked by poachers, with adverse consequences for national and international economy, ecosystems, and the safety of wildlife protectors. Forensic science could play a significant role in assisting to bring poachers to justice by producing objective evidence for court. Determining the post-mortem interval (PMI) to construct a sequence of events of a crime, could be useful for a wildlife forensic investigation. Several dating techniques have been explored extensively for human PMI determination. However, most of these techniques have shown large error margins, cannot be applied to animals, and/or are not yet assessed and validated for non-human PMI determination. Diffuse reflectance spectroscopy (DRS) has shown to be a precise and reproducible method for human bloodstain age determination. In this proof-of-concept study, the accuracy of reflectance spectroscopy for non-human bloodstain age determination has been tested. As, to the best of my knowledge, no measurements of bloodstains on natural (not plain) substrates have ever been performed, the possibility to determine the age of a bloodstain found on a natural substrate, such as sand, which is of paramount importance in wildlife forensics, was explored as well. It is shown that by determining the fractions of three haemoglobin derivatives by applying a light transport theory, non-human bloodstain age can be determined for undiluted blood, diluted blood and blood extracted from sand: 95 % of the estimates was estimated correctly within 1.06 days, 16.5 hours, and 1.05 days, respectively, for bloodstains of up to 7 days old. Since sample sizes were relatively small, further evaluation of the conclusions of this study is required.</p>

Forensic Chemistry

Student	Bence Dallos
<i>Research carried out at</i>	TNO
<i>Supervisor</i>	Mirjam de Bruin-Hoegée MSc
<i>Title thesis</i>	Exploring distinguishing markers in chlorine gas and bleach-exposed concrete samples for forensic casework
<i>Abstract</i>	<p>The threat from the use of chlorine gas as a chemical weapon in war zones continues to persist today. For the verification of chlorine gas use, forensic scientists need to investigate alternative environmental samples, such as concrete which is the most abundant material in the world and therefore is likely to be encountered at the scene. Exploring marker compounds in concrete formed due to chlorine gas exposure that can be distinguished from bleach exposure is pivotal. This is because both chlorinating agents may lead to the formation of indistinguishable markers, undermining the method's validity. This study, therefore, sets out to investigate whether it is possible to distinguish between chlorine and bleach exposure in concrete. Two different types of concrete samples are exposed to various concentrations of chlorine gas and types of bleach. Solvent extraction is used to extract any chlorinated markers for chlorine gas and bleach exposure. Various solvents for gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-high resolution mass spectrometry (LC-HRMS) are tested for their extraction efficiencies of chlorinated compounds. GC-MS samples prepared in organic extraction solvents are seen to be unsuitable for the instrument. For LC-HRMS samples, acidic water (1% formic acid) is found to be the most efficient extraction solvent. In the search for reliable distinguishing markers for chlorine and bleach exposure, tetrachlorophenol (TeCP) is probed. TeCP is identified in dichloromethane (DCM) extracted chlorine samples during gas chromatography-tandem mass spectrometry (GC-MS/MS) measurements. The potential markers for bleach and chlorine exposure, dichlorophenol (DCP) and trichlorophenol (TCP), are found across three extraction solvents. Based on admixtures in concrete, 9-chloro-10-hydroxyhexadecanoic acid and octachloronaphthalene are highlighted as potential concrete-related markers for bleach and chlorine gas exposure in LC-HRMS samples. Principal component analysis (PCA) and linear discriminant analysis (LDA) is seen to be able to distinguish between chlorine and bleach-related compounds that are observed to group together. Though the present study demonstrates that it is possible to differentiate between chlorine and bleach exposure in concrete further research using alternative experimental set-ups and additional concrete samples is required to better understand any markers formed.</p>

Student	Tim Laning
<i>Research carried out at</i>	Trimbos
<i>Supervisor</i>	dr. Laura Smit-Rigter
<i>Title thesis</i>	Characterization of a portable NIR instrument for qualitative and semi-quantitative analysis of MDMA in ecstasy tablets
<i>Abstract</i>	<p>Chemical analysis of illicit drugs is crucial in a range of work environments such as forensic organisations or drug checking systems. These organisations usually make use of expensive benchtop analysis methods which require expert operation. In order to provide fast analysis results and to be able to perform analysis on-scene, a new method is desired. A possible technique which fits these criteria is near-infrared (NIR) spectroscopy. Using data from NIR spectroscopy in chemometric models leads to promising results. The main aim of this study is to construct a decision framework for reliable detection of 3,4-methylenedioxymethamphetamine (MDMA) by using a NIR instrument in combination with chemometric models. This framework should result in a very low amount of misclassifications and accurate quantification. A large set of street samples were acquired for this project which were used to develop, test and tune four different chemometric models of which two eventually proved suitable to use in the decision framework. The framework that is constructed makes use of certain operator decisions which act as quality checks. If the sample to be analysed does not conform to these quality checks, the results of NIR measurements could be unreliable and therefore, the sample has to be sent to a laboratory for chemical analysis. After the sample passes these quality checks and the operator performs the NIR measurement, the sample data is used in a classification (NAS) model and a qualitative (PLS) model. Within both of these models, certain quality checks are inserted in order to help deliver the most accurate results. When this framework is put into practice, high performance can be achieved. Although the decision framework has not been made error-free during this project, it has shown very promising results in its current state, and a step in the right direction has been taken.</p>

Student	Sofie Lazeroms
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	drs. Irene van Damme MSc
<i>Title thesis</i>	Background and Transfer of KClO ₄ /Flash Powder
<p>Abstract</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> </div> <p><small>Figure 1. Graphic overview of the experimental procedure for the transfer study (experiment 4). The following steps were taken: 1. Distribution of 75 mg flash powder 2. Placing a hand in flash powder 3. Dispersion of flash powder over the hand 4. Using the selected object (mug, glass, plastic water bottle, dish cloth) 5. Sampling both the hand and the object with 4 alcohol pads. Alcohol pads were stored in polypropylene jars in pairs of two. Dish cloths were cut in 16 square pieces, of which one was used every experimental round.</small></p> <div style="text-align: center;"> </div> <p><small>Figure 6. Box-and-whisker plot of the transfer ratios for the mug (M), glass (G), and bottle (B) of the different subjects.</small></p>	<p>This study was part of the INHERIT project, aimed at preventing terroristic attacks by intervening across multiple stages of the terrorism timeline. Part of the project included the development of an activity level evaluation method of explosive traces, for which knowledge on the background, transfer, persistence and recovery was needed. In this paper, the background levels and transfer of perchlorate, the indicator for the presence of flash powder, were studied. The background study included sampling the hands of individuals working in the waste processing industry with alcohol pads. IC-MS analysis of the samples showed that no perchlorate was found. In addition, the effect of smoking and urinating in standing position (for male individuals) on the presence of explosive-related ions (perchlorate and thiocyanate) on the hands was researched. It was found that both activities did not lead to the detection of these explosive-related anions. A transfer study was set up to investigate the transfer behaviour of flash powder from hands ($n = 4$) to various objects (mug, drinking glass, plastic water bottle, cotton dish cloth). These differences in transfer can be used in the forensic setting to optimize house search procedures. From the IC-MS results it was clear that transfer occurred to all of these objects. The highest transfer was observed to the dish cloth, followed by similar transfer to the other objects.</p>

Student	Xing Yu Pan
<i>Research carried out at</i>	KWR
<i>Supervisor</i>	dr. Tessa Pronk
<i>Title thesis</i>	Predictive modeling of per- and polyfluoroalkyl substances (PFAS) in surface water using machine learning approaches
<i>Abstract</i>	<p>Contamination of per- and polyfluoroalkyl substances (PFAS) in drinking water is a critical concern, posing risks to both public health and wildlife. PFAS exposure has been linked to various health issues including liver damage, decreased birth weight, and increased risk of cancer. Traditional monitoring methods have fallen short in accurately assessing the extent of PFAS contamination in the Netherlands due to cost and time constraints, as well as variations in analysis methods leading to different detection limits. Consequently, monitoring data gaps have potentially extended PFAS exposure in unrecognized risk areas in the meantime. This study investigates the application of supervised machine learning models, including XGBoost and random forest regressor, for continuous prediction of perfluorooctanoic acid (PFOA), a prominent PFAS compound. These models are compared with a dummy baseline model for their relative predictive ability by leveraging a dataset that combines water contaminant measurements with meteorological, geological, and hydrological site characteristics. In general, the XGBoost model demonstrates superior results compared to the baseline dummy model and the random forest model, achieving an adjusted R^2 score exceeding 0.70. Feature importance analysis reveals strong interrelations among PFOA and other PFAS compounds, and underscores the significance of non-PFAS substances, like nickel, in model prediction. Furthermore, the study demonstrates the effectiveness of a pared-down feature subset in enhancing the model's applicability. This streamlined model bridges gaps in historical monitoring data and generates hazard maps pinpointing potential high-risk areas across the Netherlands. The current study proposes integrating the XGBoost model into risk-based monitoring to prioritize future testing initiatives and mitigate the risks posed by PFOA in aquatic systems. Consequently, this approach holds promise in reinforcing water quality management strategies and enhancing the understanding of contamination events in the context of environmental forensics.</p>

Student	Karlijn Werkman
<i>Research carried out at</i>	Avans University of Applied Sciences
<i>Supervisor</i>	dr. Jos Brouwers
<i>Title thesis</i>	Molecular networking of truxillines and other alkaloids for cocaine batch differentiation
<i>Abstract</i>	<p>The cocaine market is the second largest illicit drug market in Europe and is still growing. Cocaine use is associated with health and social problems of users, and violence in the market and corruption of port employees increasingly threaten society. In order to respond to the current situation, it is important to improve forensic intelligence regarding drug detection, monitoring and analysis. Here, we present an untargeted ultrahigh performance liquid chromatography quadrupole time-of-flight mass spectrometry method to obtain a full chemical profile of seized cocaine samples. Using a molecular networking approach, we have identified truxillines and related alkaloids as potential determinants for batch differentiation. Truxillines are tropane alkaloids formed by photodimerization in coca leaves, which naturally occur as eleven different isomers. They are interesting markers for cocaine profiling, because total truxilline content and relative distribution of the isomers varies with geolocation of the production site and production process. A principal component analysis has shown that based on these compounds, it is possible to differentiate between seized cocaine bricks. Truxillines and related compounds have also been identified in six drug waste samples containing cocaine residues, demonstrating their potential for drug waste analysis. The identified compounds can provide valuable strategic and tactical information about drug production and trafficking and can aid in combating the expanding cocaine market and its associated threats.</p>

Forensic Medicine

Student	Sienna Arnold
<i>Research carried out at</i>	UAMC
<i>Supervisor</i>	Tristan Trap MSc
<i>Title thesis</i>	Cognizance of Fire: Estimating exposure temperature of human bones using Fourier-Transform Infrared Spectroscopy
<i>Abstract</i>	<p>The destructive nature of fire and its impact on bone composition presents important challenges for forensic investigations, especially in terms of identification. Evidence collected from fire scenes informs diverse inquiries, including the identification of the deceased, assessment of facts surrounding the incident, as well as the overall reconstruction of events. The accurate analysis of thermally altered human remains is essential in forensic investigations involving fire-related incidents.</p> <p>When bones are exposed to any level of heat, they undergo a range of transformations, spanning from macroscopic to microscopic changes. In cases involving fires, human remains are often reduced to charred bone fragments which makes the use of conventional analysis techniques complicated, to impossible. Nevertheless, if the level of heat exposure remains under a certain threshold (around 400°C) and the organic component of the bone sample isn't fully combusted; DNA analysis of burned bones remains a possibility. However, if the threshold is surpassed, it is important to mention that radiocarbon dating is still a possible investigative route up to much higher levels of temperature exposure. Therefore it is crucial to estimate the exposure temperature of unknown burned bone samples as the results prove crucial in guiding forensic scientists' further analyses and investigations.</p> <p>This study aims to explore the heat-induced compositional changes in human bones in order to develop an exposure temperature estimation model based on data previously collected using Fourier-Transform Infrared (FTIR) Spectroscopy. This project builds and expands upon past research, and introduces an innovative model for the estimation of exposure temperature based on FTIR analysis. The model provides estimations in the form of temperature ranges that are linked to the phases of heat induced compositional changes. While the model demonstrates promising accuracy, further research, validation, and collaboration with forensic practitioners is essential for refining the model and ensuring its real life applicability.</p>

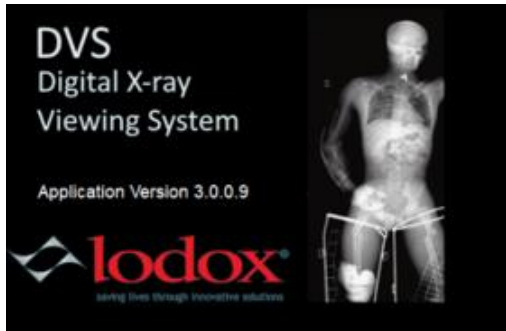
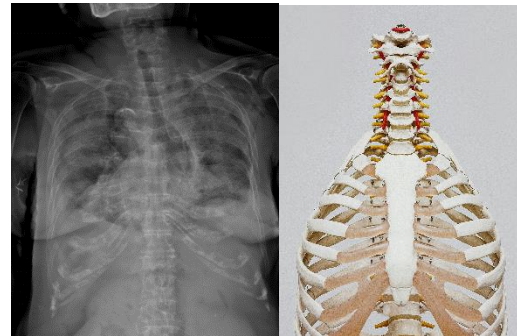
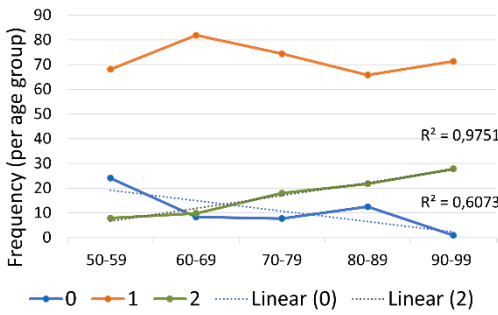
Student	Simona Gazzera
<i>Research carried out at</i>	Victorian Institute of Forensic Medicine
<i>Supervisor</i>	prof.dr. Dimitri Gerostamoulos
<i>Title thesis</i>	Evaluation of rapid forensic toxicology in the medico-legal death investigation process in Victoria, Australia
<i>Abstract</i>	<p>Aim: The medico-legal death investigation at VIFM relies on several information, toxicology findings included. Rapid overnight toxicology (ROT) can be requested since 2009 with results ready to the pathologist and the coroner within 24h. Such priority allows to inform autopsy decisions early in the investigation process, but also increases work pressure for the toxicology staff. The objective of this study was to assess the pattern of drug testing requests to make recommendations for a more consistent decisional framework, which would allow for cost and staff savings. The drugs' prevalence in overdose deaths (2021-2022) which underwent ROT was also assessed, to investigate Victorian drug trends.</p> <p>Methods: A retrospective analysis of 861 closed coronial cases (2021-2022) which underwent ROT was performed. Cases were classified according to their official cause of death and a subsample (n=145) was submitted to VIFM pathologists to be reviewed. Their decision-making process was analysed in terms of toxicology testing and autopsy requests. In 454 fatal intoxication cases the most prevalent drug classes were investigated as a whole and according to sex and age groups.</p> <p>Results: Overall 51% (n=74) of the reviewed cases would have not required ROT according to the pathologists. However, 96% (n=139) of all requests for this testing regime in the subsample were originally made by the Coronial Admissions & Enquiries staff, rather than the pathologists, resulting in several discrepancies regarding the actual need for ROT testing. Approximately 37% (n=132) of drugs present in the ROT drug testing panel were detected at least once in the analysed drug overdose deaths. Prescription drugs (non-opioids)(67%) , benzodiazepines (65%) and heroin (50%) were the most prevalent drugs, with heroin deaths likely underreported.</p> <p>Conclusions: The purpose of requesting ROT could be clarified to the CA&E staff through training sessions. Guidelines could be introduced to facilitate toxicology regime decisions by only requesting ROT testing in specific circumstances. In turn, budget savings, reduced work pressure, and more time allocated to research could be achieved. Artificial intelligence models could be implemented to assist pathologists and allow for toxicovigilance, particularly on social media.</p>

Student	Mus Leijtens
<i>Research carried out at</i>	GGD Amsterdam
<i>Supervisor</i>	dr. Maartje Goudswaard
<i>Title thesis</i>	The Decision-Making of the Court in Criminal Cases of Grievous Bodily Harm in 2022 in the Netherlands
<i>Abstract</i>	<p>Abuse is the most prevalent crime in the Netherlands. When the injuries are severe for the victim, this is called grievous bodily harm. However, that term is not strictly defined by Dutch law. This leaves room for interpretation by the court. A recent judgement by the High Council provides guidance for assessing grievous bodily harm, by addressing the nature of the injury, need for medical intervention and prospect of (complete) recovery. Verdicts need to be substantiated thoroughly, because this is essential for the principle of equality. The current research investigated three factors of the decision-making by the court. Case law for one year of potential grievous bodily harm verdicts in the Netherlands was analysed and scored for the type of medical information, the type of injury and the substantiations by the court for or against grievous bodily harm. The substantiation was categorized in twelve criteria. These were derived from the law (Art. 82 Sr), the summary judgement from the High Council and case law examples mentioned in this summary judgement. The results show that significantly more medical information is available in cases of grievous bodily harm. Moreover, some verdicts seem to have discrepancies concerning similar injuries. Lastly, the criteria that are mostly mentioned are derived from the summary judgement. Further research could investigate the role of the public prosecution in these verdicts or zoom in on a specific type of injury, such as blunt force to the head.</p>

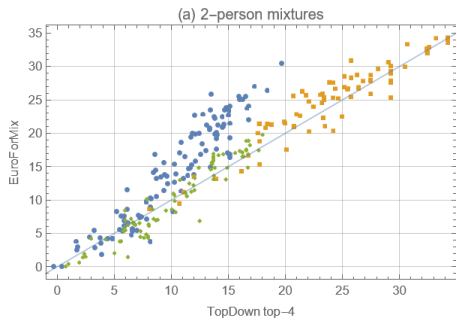
Student	Dominique van Pelt
<i>Research carried out at</i>	GGD Amsterdam
<i>Supervisor</i>	dr. Manon Ceelen
<i>Title thesis</i>	Sodium azide/nitrite suicides in the Netherlands between 2015 and 2022
<i>Abstract</i>	<p>In 2017, 'right-to-die-organisation' Cooperative Last Will introduced the legally available and existing chemical sodium azide as a method of suicide. Sodium nitrite was found as an alternative by members of the cooperative. This announcement in 2017 caused commotion in society. In this study, we investigated how many sodium azide/nitrite suicides were reported, as well as characteristics of the decedents. Based on the registration of forensic medical services in the Netherlands and data from Statistics Netherlands, an observational study was conducted into the number of sodium azide/nitrite deaths in the period 2015 to 2022 for specific regions. The number of sodium azide/nitrite suicides in the period 2015 until 2021 was compared to the total number of suicides and suicides by auto-intoxications in that same period. During the study period from 2015 to 2022, 171 suicides were identified on the basis of post-mortem reports drawn up by forensic physicians in which sodium azide/nitrite was used. During the study period, the peak of sodium azide/nitrite suicides was in 2021. About half were male (54%). The mean age of male, female and total sodium azide/nitrite suicides was 57, 62 and 59 years, respectively. The age group in which most sodium azide/nitrite suicides occurred was 70+ years. This study is the first to our knowledge to investigate the numbers of sodium azide/nitrite suicides and the associated characteristics of the individuals in the vast majority of the Netherlands. The numbers appear to be declining after peaking in 2021. The people reached by CLW were mainly the elderly of 70 years and older, but also some younger adults seemed to be reached. More research to investigate characteristics on the individuals should be done in order to create accurate suicide prevention methods in the future.</p>

Student	Rita Raymundo Carlota
<i>Research carried out at</i>	VU
<i>Supervisor</i>	dr. Sofia Moco
<i>Title thesis</i>	Transcriptomic characterization of cytochrome P450 isoforms in hepatic cell models – the metabolism of benzodiazepines as a case study
<i>Abstract</i>	<p>Humans deal with constant exposure to chemicals, whether through nutrition, environment, medicine, or even involuntary exposure. Cytochrome P450 monooxygenases (CYPs) are responsible for the biotransformation of thousands of endogenous and exogenous compounds including many drugs of abuse, such as benzodiazepines. Over the last few years, the consumption and appearance of new benzodiazepines, as well as the facility to purchase such drugs on the illicit market, have raised some concerns in the forensic community. Therefore, from a toxicological point of view, there is an increasing need to characterise and understand how these compounds are bio-transformed in the human body. Thus, metabolic studies are an important line of research in forensic toxicology since the presence of certain metabolites can, for example, allow the detection of drug abuse. Moreover, it is crucial to conduct such studies using models that could more accurately depict what occurs in the human body. Cellular human hepatic models offer important advantages in the study of xenobiotic metabolism when compared to in vivo models. Nonetheless, the transcriptomics and proteomics characterization of these models was not fully achieved. In this study, we aimed to characterise the expression of CYP isoforms in undifferentiated cells (SBAD2- 3X) and different human hepatic cell models: HepaRG, HepG2 (and mHepG2), and hepatocyte-like cells (derived from iPSCs).</p> <p>Real-time quantitative polymerase chain reaction (RT-qPCR) was used to relatively quantify the expression of 9 CYP isoforms in the cell models above mentioned. Additionally, the impact of adding isoform-specific CYP substrates on the expression levels of various CYPs was addressed. It was possible to observe that these substrates affect the expression of CYP2 and CYP3 oppositely, becoming an important finding for studies that are mainly focused on only one of these subfamilies (generally CYP3A). Moreover, liquid chromatography-mass spectrometry (LC-MS) studies were conducted to evaluate the metabolism of two model benzodiazepines (olanzapine and midazolam) in hepatocyte-like cells. Although these compounds are both benzodiazepines metabolized by CYPs, their metabolism is non-identical evidencing the importance of developing an accurate characterization of the role and specific function of the CYP machinery.</p>

Student	Keira Sexton
<i>Research carried out at</i>	Universitat Autònoma de Barcelona, Institut de Medicina Legal i Ciències Forenses de Catalunya Unitat de Medicina Legal i Forense.
<i>Supervisor</i>	prof. dr. Ignasi Galtés
<i>Title thesis</i>	Gunshot Trauma and Osteonal Damage in Human Long Bones
<i>Abstract</i>	<p>Forensic anthropologists play a key role in skeletal trauma analysis and commonly use macroscopic features to distinguish between trauma types. However, this task can be challenging, particularly in cases of highly comminuted or incompletely recovered fractures. To address this, histological techniques may help provide information through the analysis of microscopic fracture characteristics in fractured bones. This study analysed microcrack damage to the osteons and identified four types of osteonal damage in long bones with blunt force trauma (BFT) and gunshot trauma (GST) from traumatic death cases and experimental fractures. The results indicated greater osteonal damage in the GST samples when compared to BFT samples although the difference was not significant. The samples were also considered in terms of compression and tension regions for BFT samples and bullet entry and exit regions for GST. In BFT samples, greater osteonal damage was found in the tension region when compared to the compression regions. In GST samples, no significant differences in terms of osteonal damage could be noted between entry and exit regions. Osteonal damage types were also considered in all samples whereby osteonal damage affecting the inside of the osteon (contact with the Haversian canal) was found to be indicative of BFT. When all four defined osteonal damage types were equally present in samples this was found to be characteristic of GST. A dry bone sample with taphonomical trauma (BFT) had significantly greater osteonal damage affecting the cement line and interstitial lamellae. This type of osteonal damage was found to be paradigmatic of bone with brittle behaviour when fractured. This study also found that experimentally produced GST had significantly similar results to traumatic death cases with GST from mass graves. We thus conclude that there are distinct osteonal damage patterns in BFT and GST. Overall, these findings support our hypothesis that histological analysis of osteonal damage in human long bones could help distinguish between BFT and GST.</p>

Student	Lufuno Tshivhase																								
Research carried out at	AMC																								
Supervisor	prof.dr. Desiré Brits																								
Title thesis	Exploring the feasibility of developing costal cartilage based age-at-death estimation method using lodox statscans: a pilot study on an elderly white south African population.																								
<p data-bbox="185 443 288 477">Abstract</p> <div data-bbox="185 495 692 824">  </div> <div data-bbox="185 882 703 1216">  </div> <div data-bbox="204 1317 703 1630">  <table border="1" data-bbox="204 1317 703 1630"> <caption>Estimated data from the line graph</caption> <thead> <tr> <th>Age Group</th> <th>Ossification Level 0</th> <th>Ossification Level 1</th> <th>Ossification Level 2</th> </tr> </thead> <tbody> <tr> <td>50-59</td> <td>23</td> <td>68</td> <td>8</td> </tr> <tr> <td>60-69</td> <td>10</td> <td>82</td> <td>10</td> </tr> <tr> <td>70-79</td> <td>8</td> <td>75</td> <td>18</td> </tr> <tr> <td>80-89</td> <td>12</td> <td>65</td> <td>22</td> </tr> <tr> <td>90-99</td> <td>2</td> <td>70</td> <td>28</td> </tr> </tbody> </table> </div>	Age Group	Ossification Level 0	Ossification Level 1	Ossification Level 2	50-59	23	68	8	60-69	10	82	10	70-79	8	75	18	80-89	12	65	22	90-99	2	70	28	<p data-bbox="735 443 1410 1724">As life expectancy rises worldwide, bridging the research gap in age-at-death estimation methods for the elderly becomes increasingly crucial. The advancement of medical imagery offers forensic anthropology new and accessible avenues for examining additional features that could help address this gap. The examination of costal cartilage ossification is one such example. This study aimed to assess the feasibility of developing an age-at-death estimation method for the elderly by assessing the visibility and measurability of costal cartilage ossification patterns using Lodox Statscans. Ninety-seven Lodox Statscans were assessed based on five criteria: visibility, pattern, position, severity, and measurement of the ossification segment (where present). The repeatability of the criteria was assessed and subsequently, the study attempted to correlate the scores with age and sex. Visibility issues were encountered in 72% of the sample, making measurements unfeasible. The substitution of measurements with a qualitative variable, specifically severity level, proved more successful. Findings indicated fair to substantial levels of repeatability, and moderate correlations were identified between ossification presence/severity and increasing age. Notably, ossification of costal cartilage 4, 5, and 6 exhibited the strongest correlation with age. Moreover, the frequency of moderate and extensive ossification levels increased with age, reaching a peak in the 90-99 age group. This sample also showed that the pattern of ossification is indeed sex dependant – however visibility, position and severity was not. This study found that given a few recommendations namely, for a larger sample size, intensified researcher training, and a focus on specific costal cartilages, an age-at-death estimation method based on costal cartilage ossification scoring, visualised on Lodox Statscans is feasible. This study underscores the potential of Lodox Statscans as a practical tool in forensic anthropology, offering valuable insights for future research and forensic applications.</p>
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Forensic Statistics and Mathematics

Student	Dion van der Meulen
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	prof. dr. Klaas Slooten
<i>Title thesis</i>	A comparison of the TopDown approach with EuroForMix for the analysis of DNA mixture profiles
<p data-bbox="185 461 288 488"><i>Abstract</i></p> 	<p data-bbox="663 461 1410 875">The presence of genetic material from multiple contributors presents a challenge in forensic DNA analysis. Especially when a trace profile has a high number of contributors, continuous DNA-models such as EuroForMix have an unreasonably long computation time. It is mainly for this reason that the TopDown model has been developed. The rationale behind this likelihood ratio (LR) model is that it will target contributors that contributed the most to the profile, with the number of contributors that it may target as setting of the model. This makes the model eligible to perform computations on profiles with, say, five or more contributors, since the minor contributors will not act as disruptors.</p> <p data-bbox="663 887 1410 1357">This report provides a comprehensive comparison between the TopDown model on the one hand and EuroForMix and STRmix on the other, with the emphasis on EuroForMix. We used the extensive PROVEDIt DNA dataset to assess the overall performance and the similarity between these models. In line with prior expectations, TopDown showed a more conservative behaviour compared to EuroForMix for LR's from true contributors. Discrimination performances of each model has been assessed by using an ROC-curve, and this showed that EuroForMix and STRmix have a slightly better discrimination power than TopDown. Different metrics were used to determine the variability in LR results between EuroForMix and STRmix, where the highest similarity was obtained on two-person mixtures.</p> <p data-bbox="663 1368 1410 1570">Furthermore, a process called sequential searching was tested where contributors are searched in a DNA database by conditioning on reference profiles that retrieve the highest LR that exceeds a certain threshold. This process appeared to find more donors, on average, when they were present in this database.</p> <p data-bbox="663 1581 1410 1783">Limitations in this research are mostly characterized by restrictions of the data that were used for the LR computations. Therefore, future recommendations consist of performing similar comparisons using a more extensive dataset of DNA profiles, more reference profiles or different parameter settings.</p>

Student	Aafje de Rijdt
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	dr. Rolf Ypma
<i>Title thesis</i>	Further Development and Evaluation of an mRNA-based Model for Calculating Likelihood Ratios of Body Fluid Presence in Forensic Mixtures
<i>Abstract</i>	<p>In forensic cases, it is often highly relevant to identify the type of body fluids present in a crime stain. In alleged sexual assault cases, the presence of the body fluids vaginal mucosa, and menstrual secretion is often requested for analysis. Current body fluid identification techniques make use of messenger RNA (mRNA). However, the current strategy of comparing the number of detected mRNA markers to a threshold value can result in the loss of important information about body fluid presence. Therefore, in recent research, a machine learning model was developed to assess the likelihood ratio that a crime sample contains the body fluid of interest. However, the current model approach does not account for the possible composite nature of the body fluid menstrual secretion. As a result, the analysis of body fluid presence is now restricted to a combination of vaginal mucosa and/or menstrual secretion, while a separate evaluation of those body fluids is also desired. This work investigates two novel approaches to resolve this limitation. One of the novel approaches is shown to improve the original approach, by enabling the separate analysis of the relevant body fluids. Moreover, it was investigated whether the experimental dataset of the original model is representative of samples from casework. The examined case samples suggest that the samples in the original dataset may have been of poorer quality. This research contributes to the field of forensic body fluid identification by improving the applicability of an existing machine learning model. This allows for reporting the strength of the evidence more effectively and consistently, which ultimately helps the judge better interpret the findings in court.</p>